An Overview of Marine Environmental Research Pertaining to West Coast Offshore Oil and Gas Development

D. Bancroft[1], R. A. Lake[2], S-L. Marshall[3] and K. Lee[4]

Proceedings of a Workshop at: Institute of Ocean Sciences, Fisheries and Oceans Canada, 9860 West Saanich Road, Sidney, British Columbia, V8L 4B2, Canada. January 8-10, 2003.

Sponsored by: Program of Energy Research and Development (PERD), Natural Resources Canada (NRCan) and Centre for Offshore Oil and Gas Environmental Research (COOGER), Fisheries and Oceans Canada (DFO)

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2003

Canadian Technical Report of Fisheries and Aquatic Sciences 2480

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by

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Ministry of Public Works and Government Services Canada 2003
Cat. No. Fs 97-6/2480 ISSN 0706-6457

Correct citation for this publication:

Bancroft, D., R. A. Lake, S-L. Marshall and K. Lee. 2003. An Overview of Marine Environmental Research Pertaining to West Coast Offshore Oil and Gas Development Can. Tech. Rep. Fish. Aquat. Sci. 2480 iii + 164 p.

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ABSTRACT

This report provides an overview of a workshop hosted by the Program of Energy Research and Development (PERD), Natural Resources Canada and the Centre for Offshore Oil and Gas Environmental Research (COOGER), Fisheries and Oceans Canada to provide information on the state of scientific knowledge that is of relevance to the possible lifting of the West Coast Moratorium on offshore oil and gas activity. The research of various scientists is presented in this report including overviews of relevant PERD research, the activities of COOGER, the National Working Group on Oil and Gas, and the National Geoscience for Ocean Management Program. The report examines the current relevance of previous West Coast research studies and the applicability of research deliverables from recent East Coast studies. Priority research areas, together with potential costs, time lines and partnerships, are identified.

RESUME

Le présent rapport rend compte d'un atelier tenu par Ressources naturelles Canada, dans le cadre du Programme de recherche et de développement énergétiques (PRDE), ainsi que par le Centre de recherche environnementale sur le pétrole et le gaz extracôtiers (CREPGE) de Pêches et Océans Canada. Cet atelier avait pour objet de fournir des renseignements sur l'état des connaissances scientifiques pertinentes en vue d'une éventuelle levée du moratoire sur les activités pétrolières et gazières au large de la côte ouest. Le rapport fait état des résultats des travaux de divers scientifiques, en présentant notamment un aperçu des recherches pertinentes effectuées dans le cadre du PRDE, ainsi que des activités du CREPGE, du groupe de travail national sur le pétrole et le gaz et du programme national de géosciences pour la gestion de l'océan. On y examine également la pertinence des recherches antérieures effectuées sur la côte ouest et la possibilité d'appliquer à cette dernière les résultats des recherches effectuées sur la côte est. Enfin, on y définit les priorités en matière de recherches, les coûts et délais connexes et les partenariats possibles.

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Objectives

The purpose of the workshop was to provide an overview of scientific information to the Program of Energy Research and Development (PERD) to assist in its development of future research programs to address environmental issues related to the development of offshore oil and gas activity on the West Coast. The workshop goals were:

- to provide overviews of relevant research activities in PERD, the Centre for Offshore Oil and Gas Environmental Research, the National Working Group on Oil and Gas (DFO) and the National Geoscience for Ocean Management Program (NRCan);
- to identify relevant research from previous West Coast studies;
- to determine what from the more recent East Coast work is applicable to the West Coast; and
- to be cognisant of relevant research activities by the academic sector and the oil and gas industry, and other government agencies within British Columbia.

The workshop objectives were achieved through a series of presentations followed by three focused working groups that provided recommendations to PERD.

Participation

Those attending the workshop included: senior science advisors from DFO and NRCan; leaders from the Centre for Offshore Oil and Gas Environmental Research, the National Working Group on Oil and Gas and the National Geoscience for Ocean Management Program; leaders from relevant PERD Programs at the Objective Level (POLs); DFO scientists with expertise in physical, chemical and biological oceanography, including fisheries; NRCan scientists with expertise in marine geology and earthquakes; Environment Canada (EC) scientists with expertise in meteorology, marine emergencies, environmental toxicity and pelagic birds; a National Research Council (NRC) scientist with expertise in marine safety; Parks Canada scientists with expertise in marine ecology; a university research manager; and an environmental specialist from the oil and gas industry. A complete list of those participating in the workshop is attached (Appendix A).

Background

Continental shelves contain a significant portion of the world's oil and gas reserves. The Geological Survey of Canada estimates the sedimentary basins in the continental shelf area adjacent to British Columbia hold reserves in the order of 9.8 billion barrels of oil and 43.4 TCF of gas, (Hannigan et al., 2001; Figure 1). The first exploration occurred in 1949 in the Queen Charlotte Island region. In 1967, Shell Canada began a drilling program off Barkley Sound, Vancouver Island. In the next two years, 14 wells were drilled in the offshore in the region from Barkley Sound north through Queen Charlotte Sound and Hecate Strait. Non-commercial levels of oil were found off the Queen Charlotte Islands and some gas was found off Tofino.

The jurisdictions of the Province of British Columbia and the Government of Canada in the area have been addressed in a number of court decisions. In 1967, the Supreme Court of Canada decided that the Territorial Seas off British Columbia, outside of bays, harbours and inland waters, belonged to Canada. In 1972, Canada made a policy decision to not approve any new exploration permits or programs in the West Coast offshore and to suspend all work obligations under existing permits (i.e., a federal moratorium). In 1976, the British Columbia Court of Appeal determined that the Strait of Georgia belonged to British Columbia, a decision upheld by the Supreme Court of Canada in 1984. In the period of 1986 to 1989, British Columbia and Canada conducted negotiations on management and jurisdiction of offshore oil and gas exploration and development, resulting in the Pacific Accord.

The potential impact of offshore oil and gas activity on the environment has been an area of concern. During the period of 1966-1969, Canada withheld exploration approval in the Strait of Georgia until a federal-private study on the effects of seismic exploration on fish stocks was completed. A number of oil spills off the west coast of the continent have increased public concern for the possibility of disasters. In 1969, an offshore rig experienced a blow-out. In the same year, the U.S. made a proposal to transport Alaskan oil south by tanker through British Columbia coastal waters and the Strait of Juan de Fuca. In 1971, the British Columbia legislature passed a resolution opposing tanker traffic off the West Coast. During the period of 1984-1986, an independent federal-provincial environment review panel was established to assess potential environmental and socio-economic effects of offshore oil and gas exploration. The final report recommended that exploration could proceed if 92 specific recommendations were met. In 1989, an oil spill from the barge *Nestucca* off Washington State moved onshore along the West Coast of Vancouver Island. In the same year, the *Exxon Valdez* oil tanker spill occurred in Alaska. This was followed by a decision of the Province of British Columbia that no offshore drilling would occur for at least five years (i.e., a provincial moratorium). Canada announced that it would not consider any development in the offshore until requested to do so by the Province of British Columbia. In 2001, British Columbia appointed an independent scientific panel to examine whether offshore oil and gas could be extracted in a scientifically sound and environmentally responsible manner. The scientific panel concluded, "there is no inherent or fundamental inadequacy of the science or technology, properly applied in an appropriate regulatory framework, to justify a blanket moratorium on offshore oil and gas activities." In the same year, an Offshore Oil and Gas Task Force visited nine northern coastal communities to listen to the views of local residents and aboriginal groups. The task force concluded that northern communities, including

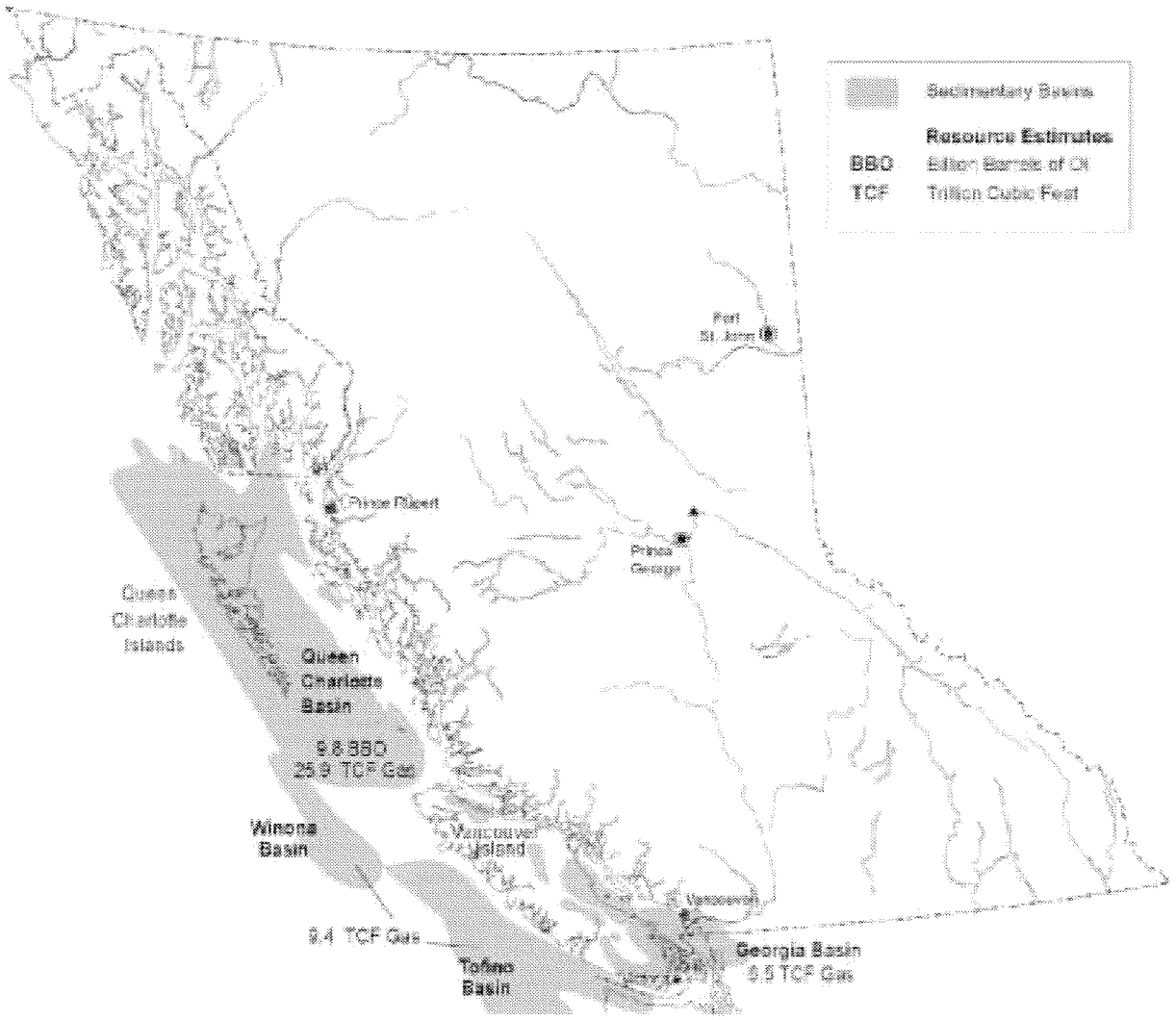


Figure 1. Offshore oil and gas potential in British Columbia. Geological Survey of Canada, unpublished. P. Hannigan, P.J. Lee, K. Osadetz et al., 1993-1998.

aboriginal groups, wanted to have a strong voice in the contemplation of offshore oil and gas. In 2002, the panel and task force made a number of recommendations for further work that needs to be done before any activity begins. In response, the Province of British Columbia enlisted the University of Northern British Columbia (UNBC) to carry out scientific and technical research and develop a work plan that responds to these recommendations.

Reference

P.K. Hannigan, J.R. Dietrich, P.J. Lee and K.G. Osadetz. 2001. "Petroleum resource potential of sedimentary basins on the Pacific Margin of Canada." Geological Survey of Canada. Bulletin 564.

Presentations with corresponding discussions

Workshop outline and ongoing research program overviews

*Editors' note: The discussions following each presentation are transcribed from a recording of the proceedings. In some cases, the text was edited to improve coherence, and reviewed by some presenters to ensure technical correctness. A small portion of the discussion was lost due to background noise and/or technical errors associated with the recordings. Also, some of the slide and image quality is limited. Please contact the appropriate authors if you would like a higher quality version of their presentation.

West Coast Offshore Oil & Gas Workshop R&D and PERD

Introduction and Purpose of the Workshop

D. Bancroft

Fisheries and Oceans Canada

Program of Energy Research and Development
Programme de recherche et de développement énergétiques

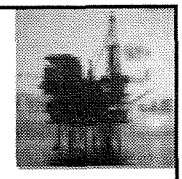
West Coast Offshore Oil & Gas Workshop R&D and PERD

Douglas Bancroft
DFO Science Oceanography & Climate
Sheri-Lynn Marshall
NRCan Office of Energy Research and Development

Centre for Offshore Oil and Gas Environmental Research

Fisheries and Oceans Pêches et Océans | Natural Resources Canada Ressources naturelles Canada

Background



- 1949 First reported drilling
- 1959 - 1967 Jurisdictional disputes
- environmental issues emerge
- 1967 Supreme Court decision
- 1967 Shell Canada begins drilling

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Background (continued)

- 1970 -1984 Ownership dispute - Strait of Georgia
- 1971 BC opposes tanker traffic off the west coast.
- 1972 federal moratorium
- 1981 BC designates that oil & gas landward of west coasts of Queen Charlotte and Vancouver Islands reserved to BC
- 1984-1986 Independent Federal-Provincial Environmental Review Panel established
- 1986-1989 BC and Canada conduct negotiations on management and jurisdiction

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Background (continued)

- 1989 Oil spills from barge Nestucca and Exxon Valdez spills - provincial moratorium
- 1998 GSC hydrocarbon assessment increased to 43 trillion cubic feet of gas and 10 billion barrels of oil
- 1999 BC northerners support the development of a process to reconsider the provincial moratorium.
- 2001 BC appoints independent scientific panel to examine offshore oil and gas
- 2002 The panel concluded: "there is no inherent ... inadequacy ... to justify a blanket moratorium

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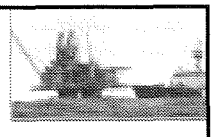
Federal Status



- CEAA process
- federal decision on lifting moratorium will await
- Federal government is:
  - assessing what work needs to be done
  - carrying out preliminary consultations
  - developing action plan
- Preliminary action plan developed

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Workshop Goals

- Provide an overview of PERD
- Provide an overview of COOGER
- Present key PERD oil and gas research work that would likely be relevant to west coast oil and gas
- Working Groups to tackle specific questions

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Working Groups goals:

- Determine what "knowledge" derived from PERD east coast work is applicable to the west coast
- identify specific west coast gaps applicable to PERD activity
- develop possible projects, and activities best tackled by PERD,
  - how to integrate these with PERD structure

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AGENDA - Wednesday

- Introduction & purpose. D. Bancroft (DFO)
- Administrative Info. B. Lake
- PERD Overview. SL. Marshall (NRCan)
- National Working Group. G. Faulkner (DFO)
- COOGER K. Lee (DFO)
- West Coast - features, accomplishments, and requirements. W. Cretney (DFO)
- West Coast marine geoscience. V. Barrie (NRCan)
- West Coast earthquake hazards. G. Rogers
- CAPP - industrial interests. TBD

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AGENDA - Thursday

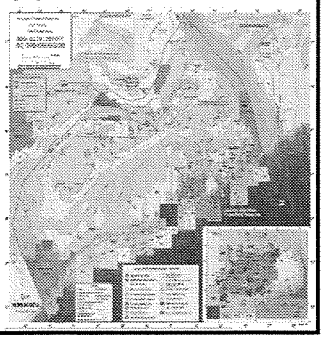
- Presentations from the community linked to ongoing and past East Coast PERD projects.
- POL 1.2.1. Offshore Environmental Factors.
  - P. Smith. D. Pickrill
- POL 1.2.3. Marine transportation and safety. R. Frederking.
- POL 1.2.4 Offshore Environment Impacts.
  - Overview. H. Bain and K. Lee; then presentations by PIs

AGENDA - Friday

- Objectives. D. Bancroft and S. Marshall
- Needs: What are they ? How to address? Who? When? Where? Why PERD?
- Working groups:
  - what PERD work applicable to the West Coast
  - Identify specific West Coast gaps for PERD Brainstorm project ideas, proposed activities that could build on existing work
  - Discuss program partnerships.

East Coast Offshore oil & gas experience

To date, PERD R&D critical to support ongoing protection of the marine environment



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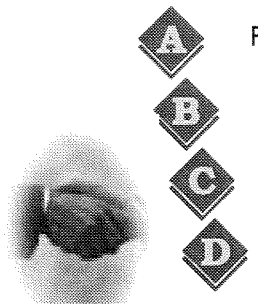
Workshop hopes to Build on Existing PERD Partnerships



Federal Departments

Agencies

Industry

Regulators

thank you for being here

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Oil and Gas Activities in the Program of Energy Research and Development (PERD)

Overview of PERD Emphasis on Offshore Oil & Gas R&D

S-L. Marshall

Natural Resources Canada

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Oil and Gas Activities in the Program of Energy Research and Development (PERD)

Sheri-Lynn Marshall
Office of Energy Research and Development
Natural Resources Canada

Program of Energy Research and Development
Programme de recherche et de développement énergétiques

Outline

- What is PERD?
- Participants
- Structure of PERD
- Features of the oil and gas component of PERD

West Coast Offshore Oil and Gas Workshop
January 08, 2003 Sidney BC
Natural Resources Canada Ressources naturelles Canada

Program of Energy Research and Development
Programme de recherche et de développement énergétiques

Sustainable Development

- Sustainable Development is the overarching principle of energy policy
- Three Pillars of Sustainable Development
  - economic growth
  - environmental protection
  - secure (and reliable) supplies

West Coast Offshore Oil and Gas Workshop
January 08, 2003 Sidney BC
Natural Resources Canada Ressources naturelles Canada

Program of Energy Research and Development
Programme de recherche et de développement énergétiques

What is PERD?

- a unique federal program focussed entirely on non-nuclear energy R&D
- a program at Natural Resources Canada that is delivered interdepartmentally through 12 federal departments and agencies
- funding provided to, and only through, the participating federal departments and agencies

West Coast Offshore Oil and Gas Workshop
January 08, 2003 Sidney BC
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Goal

- PERD seeks to promote the development and use of Canada's energy resources in a clean and safe manner, and the development of energy efficient, renewable and alternative energy sources and technologies

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Engaging PERD

PERD funds 12 federal departments and agencies, including:

- Agriculture and Agri-food Canada
- Canada Mortgage and Housing
- Environment Canada
- Fisheries and Oceans
- Health Canada
- Indian and Northern Affairs
- Industry Canada
- National Defense
- National Research Council
- Natural Resources Canada
- Public Works and Government Services Canada
- Transport Canada

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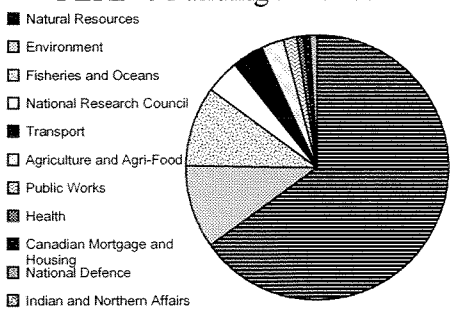
PERD's Funding Distribution



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Features of PERD

- strategic focus
- collaborative approach
- partnerships with recipients and industry
- systematic evaluation
- sound S&T expertise

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Criteria for Setting Priorities

- public interest
- role for government
- federal role
- partnership
- efficiency
- affordability

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Hierarchy of Priorities

1. To help the federal government fulfill its direct energy R&D responsibilities (standards, regulations, policy knowledge)
2. To conduct energy R&D for the public good
3. Reactive funding programs
4. Programs for demonstration, deployment, and engineering

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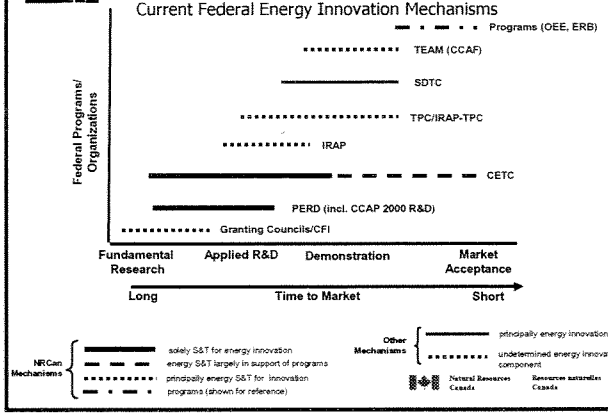
Current Federal Energy Innovation Mechanisms



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The Energy Priority Framework (EPF)

- High level overview providing an environmental scan of energy related issues and related priorities cutting across Policy, Programs, and Science and Technology

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EPF S&T Priorities

- Economic Development - Maintain and enhance energy as a stable source of comparative advantage for Canada
- Environmental Stewardship - Square the GHG reduction challenge with economic opportunities and develop new options for ongoing response to climate change
- Social Agenda - Provide S&T to maintain secure, reliable and safe energy for all regions and, in particular, rural and remote communities

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The S&T Companion Document (S&TCD)

- An S&T response to federal energy priorities
- Built from EPF priorities
- Describes the present content of the NRCan energy S&T program

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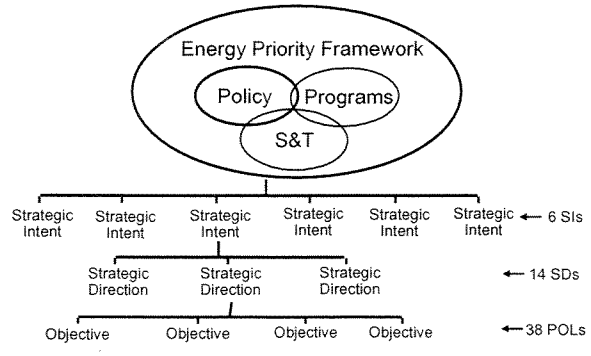

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Features of a Program at Objective Level (POL)

- A POL may contain one or more activities
- The POL plan details the activities and their associated outputs, outcomes, and impacts, as well as accountabilities
- POL committees are composed of R&D performers, OERD Advisors, and representatives from regulatory agencies, industry associations and academia
- Lead by POL Leaders selected from the PERD community
- POL Committees are primary "point of contact"

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S&T Strategic Intents

Strategic Intent 1: Fulfill federal government responsibilities while maximizing economic benefits and reducing environmental consequences from the expansion and diversification of Canada's oil and gas production

Strategic Intent 2: Foster cleaner sustainable transportation fuels and systems in order to improve the environment, reduce emissions, including GHGs, and to increase economic activity through development of domestic and export markets

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S&T Strategic Intents

Strategic Intent 3: Reduce the overall energy intensity of Canada's buildings and community systems and, consequently, their associated GHG emissions while, at the same time, providing Canadian companies with potential economic opportunities

Strategic Intent 4: Reduce the overall energy intensity of Canada's resource sectors and, consequently, their associated GHG emissions while, at the same time, improving productivity and providing Canadian companies with potential economic opportunities

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S&T Strategic Intents

Strategic Intent 5: Reduce the environmental impacts of Canada's electricity infrastructure, particularly greenhouse gases, through alternative electric power generation, increased efficiency of fossil-fueled plants and strategies to capture and manage emissions

Strategic Intent 6: Minimize the negative impacts of climate change on the Canadian energy sector

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PERD Oil and Gas Portfolio (Strategic Intent 1)

3 Strategic Directions:

1.1 Onshore

1.2 Offshore and northern

1.3 Cross-cutting environmental

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Strategic Direction 1.1

Onshore oil and gas ($6.4M + $1.2M to support the PTRC)

Program Objectives

1.1.1. Bitumen & heavy oil
1.1.2. Conversion to clean, refined petroleum products
- ❖ Heavy and conventional oil (PTRC)

*Note: For the sake of convenience, strategic directions and objectives are represented here by topic areas. They must, however, be read in their entirety to appreciate their context and related drivers

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Strategic Direction 1.2

Offshore and northern oil and gas ($4.9M)

Program Objectives

1.2.1. Offshore environmental factors
1.2.2. Oil & gas in the north
1.2.3. Transportation and safety
1.2.4. Remediation of offshore drilling and production wastes, discharges & spills

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Strategic Direction 1.3

Crosscutting Environmental Issues ($3M)

Program Objectives

1.3.1. Regulate & reduce GHG emissions (primarily flaring)
1.3.2. Pipelines
1.3.3. Remediation of groundwater and soil

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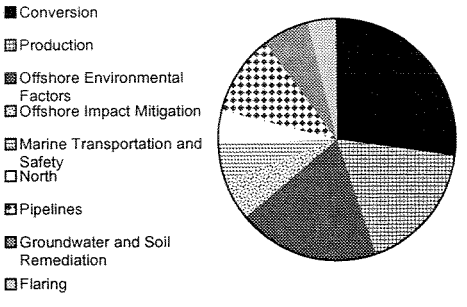
Relative funding in SD 1.2



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Summary

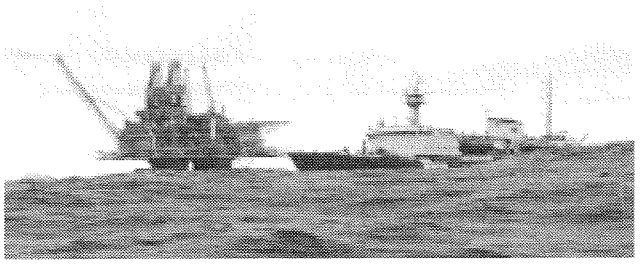
- PERD is aligned with federal responsibilities and priorities;
- PERD has broad coverage in energy S&T;
- In the oil & gas sector, 3 Srategic Directions containing 9 Programs at the Objective Level (POLs);
- PERD achieves many outputs with limited resources, thanks to partnerships.

Update on Centre for Offshore Oil and Gas Environmental Research (COOGER)

K. Lee

Fisheries and Oceans Canada

Centre for Offshore Oil and Gas Environmental Research
Centre de recherche environnementale sur le pétrole et le gaz extracôtiers



Background

- Canadian offshore oil and gas activities are expanding; many issues are emerging that require scientific knowledge to resolve.
- Research must be managed strategically by the Department to address our environmental and safety concerns related to offshore oil and gas development, exploration, and production.
- A multi-disciplinary, national approach is needed by DFO to optimize progress on current and future research initiatives and to maintain in-house expertise.

Background

- A-based funding has been limited. DFO makes significant in-kind contributions to support B-based programs (e.g. PERD and ESRF).
- New opportunities have resulted from external collaborations funded by C-Base and JPAs with industry, universities and other international government agencies.
- Need to optimize progress on research initiatives through national DFO coordination, building on existing regional expertise and infrastructure.

Role of COOGER

- Primary role:
  - Identification of R&D needs
  - Coordination of collaborative research internally and externally
  - Provision of scientific information to clients including Habitat, Oceans and Fisheries Management.

Role of COOGER

- The focus of COOGER is research.
- Review of Environmental Impact Assessments (EIAs) will be managed by regional oil and gas advisory committees.
- COOGER science members will provide advice and generic deliverables, such as science based frameworks for the review of EIAs.

Mandate and Goals

- To facilitate the development of coordinated research programs in oceanographic research related to the environmental issues associated with oil and gas activities and DFO mandates.
- To identify needs for a balanced and strategic program on oil and gas research for the Department (e.g., providing advice on priorities to national science fund programs, and co-ordination of research proposal reviews).

Mandates and Goals

- To minimize duplication of activities and roles that are being successfully undertaken by other organizations.
- To improve program deliverables and the quality of science by fostering research collaborations and identifying new sources of funds to support research.
- To improve our internal advisory capacity on oil and gas by promoting the sharing of knowledge between DFO and external sources.

Mandate and Goals

- To provide scientific knowledge including peer-reviewed publications for decision making for:
  - Formulation of improved regulatory guidelines
  - Use by internal clients such as DFO Habitat, Oceans and Fisheries Management to support their mandated needs
- To foster research partnerships with external bodies including industry, academia and public interest groups

Mandate and Goals

- To avoid a perceived conflict-of-interest situation with research partners (including industry), COOGER as an organization, will not involve itself with regulatory duties in a direct manner.
- A Statement of Principles will be drafted to address data management and distribution issues including Intellectual Property (IP).
- DFO scientists that are members of COOGER will continue to provide scientific support to internal DFO clients.

Management

- Reporting to the National Science Directors Committee (NSDC), COGER will include the participation the Science Branch from all regions and DFO HQ.
- Secretariat Office to be located at BIO.
- Managed by an Executive Committee appointed by the NSDC.

Management

Executive Committee:

- Newfoundland Region – Jerry Payne
- Maritimes Region – Kenneth Lee (Executive Director)
- Gulf Region – Ross Alexander
- Quebec Region – Michel Gilbert
- Central and Arctic Region – Marty Bergmann
- Pacific Region – John Pringle
- DFO HQ (Science Branch) – Hugh Bain
- DFO HQ (Oceans Branch) – Gail Faulkner (NWGOG)

Management

Maintain liaison with:

- Regional DFO science advisory committees
- Representatives from regulatory boards, CAPP, ESRF
- Leaders of PERD Oil and Gas Reseach POLs
- Other federal departments (e.g., NRCan, EC), academia and other research agencies with common interests (e.g., PRAC, U.S. EPA, Norwegian Pollution Control Authority)
- NGOs including environmental interest groups

Discussion

The Centre for Offshore Oil and Gas Environmental Research (COOGER) facilitates co-ordination and communication both internally within DFO and externally. COOGER seeks mechanisms to optimise the use of departmental funds for oil and gas activities by identifying opportunities to lever programs through external partnerships with industry and academia. DFO may provide less than 50% of the required resources. Partners share ship-time and other resources and participate jointly in scientific cruises.

As an example of a COOGER project, the Atlantic Canada Opportunities Agency (ACOA) promotes research programs within the private sector. COOGER interacts with private industry organisations to identify opportunities for co-operation. ACOA has considered the funding of half a Person-Year (PY) to identify a crossover of interests where spin-offs from DFO research could be developed by industry into instrument packages for the commercial market.

The private sector has the responsibility to conduct research for the support of regulatory documents such as environmental impact statements (EIS's). As there is always an issue of public perception, industry has expressed an interest in funding and co-operating in research programs managed by COOGER to provide scientific information for use by resource managers in both parties and the public.

There is a need for data to support environmental assessment resulting from offshore oil and gas activity. Data include baseline physical (e.g., wind, waves, currents) and chemical (e.g., contaminant concentrations) information required for risk assessment. Industry is responsible for providing the necessary support but they realise that government has resources (e.g. research ships) and scientific expertise not otherwise available so partnerships can be advantageous to them.

On the West Coast, the proposed time frame for offshore oil and gas development is very short. Thus, a lot of ship time and other resources may be required in the near future. Much of this is considered the proponent's responsibility, but industry is unlikely to fund a substantial research effort until the moratorium has been lifted. There is no industry activity off the West Coast at the current time to provide support to programs under the Environmental Studies Research Fund (ESRF). The Government of Canada is looking at identifying the scientific information needs required to support decisions regarding the lifting of the moratorium. There is a balance between the lack of funding for data acquisition and the need for data to allow Ministers to make an informed decision regarding the moratorium.

On the East Coast, industry has invested funds to obtain the information it needs and has become an active participant in the provision of advice to the PERD Program at Objective Level (POL) process. Industry does not fund ship time, expecting this to be provided by DFO, which has a value in the order of several hundred thousand dollars.

COOGER looks at two factors: the impact of the environment on offshore oil and gas activities and, secondly, the impact of oil and gas activities on the environment. COOGER programs are multi-disciplinary covering the biological, chemical, physical and geological sciences.

COOGER does not have programs specifically aimed at the West Coast at the present time, however, it does focus on identifying national science needs to cover oil and gas research requirements. For example, there are not enough scientists with risk assessment expertise. COOGER identifies the important issues, the key players and their roles. There are many shared concerns (e.g., seismics), many that are generic and are both national and international in scope. For example, in Nova Scotia, industry is now involved in deep water drilling operations. One concern is deep-water blowouts but this is also an international concern (e.g., the North Sea and the Gulf of Mexico). These issues should be dealt with through international programs involving DFO and other international organisations.

DFO National Working Group on Oil and Gas (NWGOG)

G. Faulkner

Fisheries and Oceans Canada

DFO National Working Group on Oil and Gas (NWGOG)

Presentation to PERD Workshop
January, 2003
IOS

Mandate

- develop and recommend nationally consistent guidelines, policies, and decision frameworks to ensure effective, efficient and consistent delivery of DFO habitat and oceans mandate and DFO CEAA responsibilities for the oil and gas sector
- provide inter-regional and intersectoral information sharing forum for Habitat Management, Oceans Management and Science
- provide advice to senior management on oil and gas projects and pipelines

Participants

- All DFO regions
- DFO National Headquarters Habitat and Oceans
- DFO Headquarters Science

Current and Ongoing Work

- Inter-regional exchange of information and expertise
- Input to COOGER through participation on the COOGER Executive
- Participation on the CEAA Regulatory Advisory Committee sub-committee reviewing CEAA regulatory amendments for offshore oil and gas

Upcoming Work

- Provide departmental science needs to COOGER
- Work with DFO Science to deliver a departmental seismic workshop culminating in the development of an operational decision framework

Discussion

A seismic workshop will take place on March 20–22, 2003 in Montreal. The workshop will develop a decision-making framework to ensure that seismic operators provide correct information and that the decisions made are consistent. The workshop will lead operators through the decision-making process based on the information they provide. There will not be a peer review of existing knowledge. The workshop will draw on external expertise from Britain, U.S. and Canada, including scientists and regulators but not operators.

Concerning how the National Working Group on Oil and Gas relates to the Centre for Offshore Oil and Gas Environmental Research (COOGER), the National Working Group consists of decision-makers, managers and regulators. COOGER draws on scientists and research and development that support decision-making. It is important for COOGER to understand what the needs are internally within the department and to have crossover between science and regulators, with COOGER providing documents to assist decision making and policy development. In the future, it is likely that the two groups will develop Memoranda of Understanding (MOU) to define roles and commonalities.

Geoscience for Ocean Management

D. Pickrill
Natural Resources Canada

GEOSCIENCE FOR OCEAN MANAGEMENT

The national marine geoscience program for Canada

Dick Pickrill

Geological Survey of Canada, Atlantic

Institute of Ocean Sciences, 8 January 2003

GOM Themes

- Integrated ocean management of large ocean management areas (LOM|A)
- Hazard potential and environmental impacts of structures
- models of geooscience controls on benthic habitat distribution
- assessing human impact on marine environmental quality
  - thematic overlap, common methodologies

Notional Program Budget

- GOM 12% of GSC
- Total $8m, 30% soft money
- approximately 60 staff
- GSC Atlantic (BIO), GSC Pacific (IOS)

GOM projects

- National mapping and informatics strategy
  - backbone project for technology develoment and informatics etc
- Ocean Management
  - East Scotian Shelf Integrated Management Plan (ESSIM)
  - Georgia Basin
  - **Queen Charlotte Basin**
- Hazards
  - **East coast offshore geohazards**
  - **Beaufort Sea, environmental conditions and hydrocarbon development**
- Benthic habitat
  - Gulf of Maine, benthic habitat mapping
- Marine environmental quality
  - coastal waters of eastern Canada

GOM soft money program alignment

- most projects have a soft money partner, 100% aligned
  - **Beaufort, - 3 year cabinet funding**
  - ESSIM - horizontality
  - CFFI &DFO habitat
  - MEQ, Environment Canada
  - **Hazards, PERD, oil industry**
  - **QCBasin, province, universities DFO**
  - Georgia Basin, universities, DFO
  - Methods, all other projects!

GOM next steps

- Feedback from the GSC Office/ADM & chief scientist
- Excellent consultative review process within GOM
  - workshops & international review
- set priorities between programs
- final program approval, April 1
- PERD West Coast workshop very timely

Discussion

Historically, marine landslides and slumping have been big issues, with studies directed toward the more active areas. In some of the canyons, backscatter from multibeam sonar has shown sand ripples at 300 m depth. On multibeam, six to ten distributory channels can be seen at the head of canyons where charts show a single channel. Sediment can be seen feeding into the channels. In general, 90% of the slope is satisfactory and focus is on the remaining 10%. There is enough information at the moment to get past the exploratory phase. The exploratory phase is much different than the production phase. During exploration there is drilling activity on site for perhaps 25 days and the risk from landslides is acceptable. Production structures are a different situation. There are examples of threats from sea slope failure. In the Gulf, slope failure occurred near a platform as illustrated by the slide of a sidescan mosaic, which showed a mudslide reaching a distance of 10-100 m from the platform.

Interactions between Geology and Habitat

There has been co-operation with the fishing industry (Clearwater Fine Foods, scallop producers) and DFO (Canadian Hydrographic Service and Fisheries Management Sector). Vladimir Kostilov has conducted habitat mapping under contract with funds from NRCan and DFO. A paper in *Marine Ecology* is in progress. The work established strong statistical links between substrate and benthic community structure that can then be mapped quickly with reasonable precision. To date, the emphasis has been on benthic communities, with the intent to move on to scallops. A full two-year, $6 million, multibeam dataset has been funded by industry. It is intended to produce high-resolution habitat maps over the Banks in the next two years.

Sediment motion has been seen at depths up to 30 m. There is a need to put sensors on platforms and to obtain data during storms. On the East Coast, there has been apparent remobilization at the shelf break, which is possibly due to internal waves. This would not apply to the West Coast, where much higher wave energy would be required.

The digital atlas includes data sets from NRCan and industry but not other departments because the work has been largely confined to the Geoscience Centre. An initiative between the two departments will try to meld data, which include benthic ecology, geology and the most recent bathymetry. New maps are planned that will have 10-15 different surfaces on a CD-ROM. There are two and a half years to go on this project.

Environmental Studies Research Funds

Overview & East Coast Projects

K. Lee

Fisheries and Oceans Canada

Environmental Studies Research Funds

Overview &
East Coast projects

Environmental Studies Research Funds

Overview

Profile

- The Environmental Studies Research Funds (ESRF) is a research program which sponsors environmental and social studies
- It is designed to assist in the decision-making process related to oil and gas exploration and development on Canada's frontier lands

Profile - continued

- The ESRF program, initiated in 1983, receives its legislative mandate through the *Canada Petroleum Resources Act* (CPRA)
- Funding is provided through levies on frontier lands paid by interested holders such as the oil and gas companies

Profile - continued

- The ESRF provides a forum for industry and government to develop a common knowledge base and to jointly design a focused study program which addresses the needs of both groups and avoids a repetition of effort and expense

Purpose

- To finance environmental and social studies pertaining to the manner in which and to the terms and conditions under which petroleum exploration, development, and production activities on frontier lands should be conducted.

Management

- Directed by a 12-member Management Board with representation from:
  - the federal government (4)
  - the Canada-Newfoundland Offshore Petroleum Board (1)
  - the Canada-Nova Scotia Offshore Petroleum Board (1)
  - the oil and gas industry (4)
  - the general public (2)

Management - continued

- Bonnie Gray, Professional Leader of Environment at the National Energy Board (NEB) currently chairs the ESRF Management Board.
- Administration is provided by a small secretariat within the NEB.

Management Board

- Sets priorities for study topics
- Determines the program budget
- Facilitates the development of study proposals

Environmental Studies Research Funds

Recent East Coast Projects

Priority Study Areas

- Offshore Waste Discharges
- Offshore Seismic Operations
- Seabirds
- Cumulative Effects
- Environmental Effects Monitoring
- Dispersants/Oil Spill Management Response
- Environmental Prediction (Weather)/Physical Environment
- Subsea Gathering Line/Pipeline Effects

Stand-Alone Studies (2002)

(not directly linked to a priority area)

- Iceberg Scour
- Deepwater Corals
- CSA Structures
- Mesocosm/Drill cuttings

Ongoing or Planned Studies

- Cumulative Effects Workshop
- Mapping of Sensitive Fisheries Areas - Nova Scotia and Newfoundland
- Effects of Seismic Energy on Snow Crab
- Seabird and Marine Mammal Study
- Sheens and Produced Water
- Pollution Prevention Opportunities

Studies - continued

- Standardizing Reporting of Air Emissions
- EEM for Exploratory Drilling
- Seabird Attraction to production Installations - Instrument-based Approaches
- Chemical Dispersant-use Workshop

Publications

- All ESRF studies are subject to a scientific/technical peer review
- Reports that are deemed to be scientifically or technically significant are published in the ESRF Technical Report Series.

Publications - continued

- Complete list of study reports published since 1983 is contained in the ESRF Annual Report
- Copies are available from the ESRF Secretariat

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Discussion

When offshore lands are leased, a contribution is made to the ESRF Fund. Money for the support of research on the West Coast under the ESRF Fund is not anticipated until the start of operations following a lifting of the moratorium. Bidding on ESRF projects is wide open, with many projects are carried out by private sector companies. ESRF is very specific about what their needs are. The process involves identifying the need and objectives and a bid call is posted. At the present time, DFO, Environment Canada and industry representatives are members of the ESRF Advisory Committees. Historically, it was intended that ESRF money would not fund government research, and only recently has the fund become available to federal laboratories. Scientific information produced under the ESRF program is now published in peer reviewed reports. This is in response to reviewers of Environmental Impact Statements (EIA) who do not accept citations from the grey literature.

PERD and ESRF differ in that ESRF topics are very specific and short-term while PERD projects are longer term. For example, there was an incident in the Gulf of Mexico involving mercury in drilling mud. ESRF very quickly had a project to look at mercury issues. Requests for Proposals (RFPs) under the ESRF program are very focused and specific while the PERD call for proposals are for much broader tasks.

To give you an idea of ESRF funding levels, the Deep Sea Corals Project received $130K in 2003 and another project was about $200K, so funding at $50-200K is typical.

Potential perception problems could exist where work is industry-driven and funded. All parties want to be ensured that results are reliable and acceptable. Under ESRF programs, the data on which reports are based are open. Data are not proprietary and reports are peer-reviewed
No funds are available until industry indicates interest in an area and exploration starts. Scientists are in a quandary as there is no opportunity or funding to do baseline studies; everything has to happen at once. There is no easy way around this as people do not want to invest unless there is potential for things moving forward. We need to keep in mind this workshop is looking at the needs in relation to exploration on the West Coast as opposed to production.

Establishing Biogeochemical Benchmarks for Source Identification of Contaminants from a West Coast Offshore Oil and Gas Industry

W. Cretney

Fisheries and Oceans Canada

Establishing Biogeochemical Benchmarks for Source Identification of Contaminants from a West Coast Offshore Oil and Gas Industry

By

Walter Cretney[1], Mark Yunker[2] and Philip Yeats[3]

[1] Institute of Ocean Sciences, Fisheries and Oceans Canada, P.O. Box 6000, Sidney, B.C. V8L 4B2, [2] 7137 Wallace Dr., Brentwood Bay, B.C. V8M 1G9, [3]Bedford Institute of Oceanography, Fisheries and Oceans Canada, P.O. Box 1006, Dartmouth, N.S. B2Y 4A2

SUMMARY OF KNOWLEDGE AND KNOWLEDGE GAPS

- Terrestrial petroleum from shows (e.g., seeps) on the Queen Charlotte Islands have been chemically characterised.
  - Both metal and hydrocarbon 'fingerprints' are available .
- Similar knowledge is lacking for submarine petroleum seeps, which are not known to exist apart from gas plumes.
  - If submarine seeps exist, marine organisms may be adapted to, or even be feeding on, petroleum residues.

SUMMARY OF KNOWLEDGE AND KNOWLEDGE GAPS (cont'd)

- No petroleum benchmarks exists for the marine environment to aid in:
  - identifying the sources of petroleum from future industrial releases
  - delineating the spatial extent and influence of pre-existing petroleum residues and
  - confirming transport pathways suggested by models.
- No database is available for marine concentrations of metals and other inorganics common to the oil and gas industry.
- No database exists for geochemical tracers (Li, Al, Fe) that can be used for normalising the sedimentary concentrations of inorganic industrial substances
  - to minimise the grain-size effect and
  - to provide reliable chemical fingerprints.

SUMMARY OF KNOWLEDGE AND KNOWLEDGE GAPS (cont'd)

- No data exist for submarine hot-water vents whose existence could
  - contribute to the variability of sedimentary concentrations of metals and
  - complicate the use of inorganic tracers for produced-water plumes in sea water.
- Vent waters may contain high concentrations of radionuclides, which are proven produced-water plume tracers
- An emerging issue is the transfer to the sea-surface microlayer of inorganic substances associated with buoyant oil particles in produced water.
  - Produced-water inorganics may affect the viability of larval forms of animals that concentrate at the sea surface.

Table 1. Fingerprinting methods for petroleum in the marine environment [1]

Fraction	Parameter	Environmental persistence	Method [2]	Source specificity	Level of effort/cost
Whole oil	Total petroleum hydrocarbons	Low/ moderate	Infrared, ultraviolet, and fluorescence spectrometry; flame ionisation; gravimetric	Low	Low
	Carbon isotopes ($\delta^{13}C$)	Moderate/ high	Isotope ratio mass spectrometry	Moderate/ high	Low/ moderate
Aliphatic	Normal and isoalkanes (C_9-C_{35}+)	Low/ moderate	GC/FID	Low/ moderate	Low/ moderate
	Saturate biomarkers (tricyclic terpanes, hopanes and steranes)	High	GC-MS (SIM)	High	High
Aromatic	Benzene, ethylbenzene, toluene, xylene, (BTEX)	Very low	Purge and trap GC/FID	Low	Moderate
	Polycyclic aromatic hydrocarbons (PAH)	Low/ moderate/ high	GC-MS (SIM)	Moderate/ high	High
	Mono- and triaromatic steranes	High	GC-MS (SIM)	High	High

[1] Table adapted from Bence et al., *Organic Geochemistry* 24: 7-42 (1996) . [2] GC = gas chromatography; FID = flame ionisation detection; MS = mass spectrometry; SIM = selective ion monitoring.

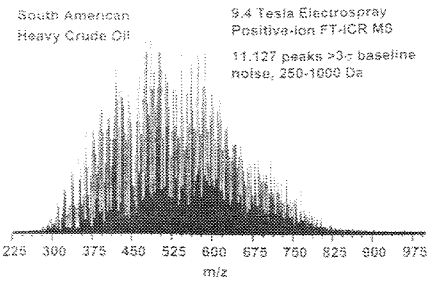

Figure 2. The most complex chemical mixture ever resolved and identified in a single mass spectrum. Resolving power, $m/\Delta m_{50\%}$, was about 350,000 from 250 to 950 Da (FT-ICR MS = Fourier Transform-Ion Cyclotron Resonance Mass Spectrometer; from Hughey et al. *Anal. Chem.* 74:4145-4149 (2002)).

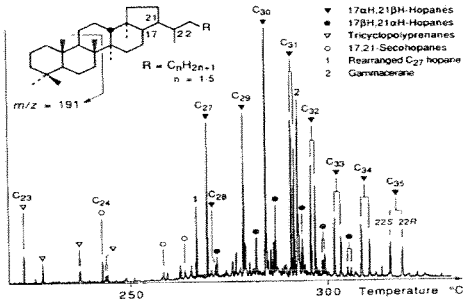

Figure 3. Mass fragmentogram (m/z 191) showing the distribution of polycyclic terpanes separated by temperature-programmed gas chromatography (from Ourisson and Albrecht *Acc. Chem. Res.* 25:398-402 (1992))

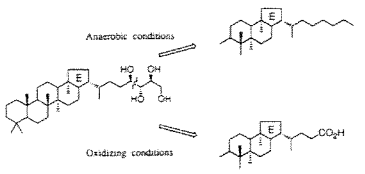

Figure 4. Diagenic transformation of bacteriohopanetetrol under anaerobic and aerobic conditions (from Ourisson and Albrecht *Acc. Chem. Res.* 25:398-402 (1992))

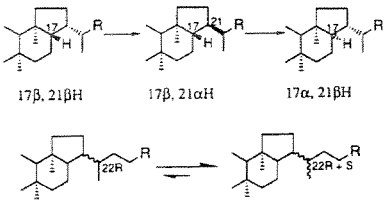

Figure 5. Structural changes in hopanoids with time and temperature. The ratios of diasteriomers ([ââ]:[áâ]:[áá]) provide a measure of "maturity" (from Ourisson and Albrecht *Acc. Chem. Res.* 25:398-402 (1992))

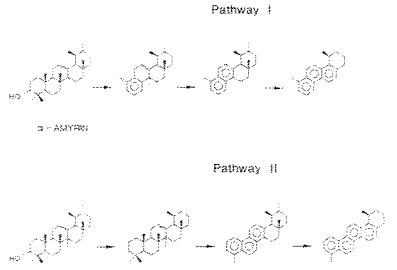

Figure 6. Formation of tetra- and pentacyclic aromatic hydrocarbons from α-amyrin (Cranwell, *Prog. Lipid Res.* 21: 271-308 (1982))

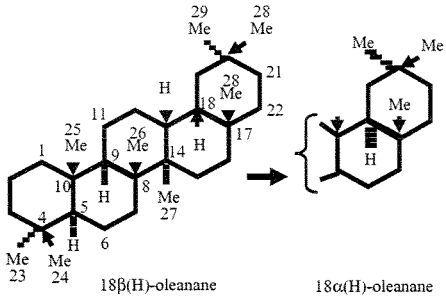

Figure 9. Conversion of 18β(H)-oleanane to its more thermodynamically stable epimer 18α(H)-oleanane

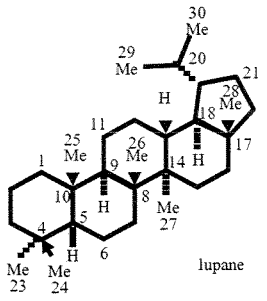

Figure 10. Lupane is a geometric isomer of 18α(H)-oleanane that coelutes with it on non-polar gas chromatography columns

Table 5. Inorganic chemical composition of produced water compared with hotspring and sea water

	Produced water[1]	Hotspring Island thermal water[2]	Sea water[3]
Salinity	1-225 ‰	3.32 ‰	27.1-34.1 ‰
NH3	0-14 mM	No data	No data
SiO2	250 µM	1600 µM	0.6-80.3 µM
Al	0.07-2.3 mg/L	0.6 mg/L	30-130 ng/L
Fe	0.12-680 mg/L	No data	4-140 ng/L
Mn	0.11-11 mg/L	No data	50-70 ng/L
Ba	0.2-342 mg/L	0.2 mg/L	4-20 µg/L
Cd	0.05-190 µg/L	No data	0.8-100 ng/L
Cu	0.2-800 µg/L	No data	0.08-0.13 µg/L
Hg	0.01-7 µg/L	No data	0.5 ng/L
Pb	0.1-840 µg/L	No data	3-9 ng/L
Zn	0.26-69000 µg/L	No data	4-500 ng/L
Ra-226	0.1-1565 pCi/L	No data	0.03-0.045 pCi/L
Ra-228	0.6-1509 pCi/L	No data	0.006 pCi/L

[1] compiled from various sources, [2] Clark, I.D. 1985. Geochemistry, isotope hydrogeology and geothermometry of hotsprings in the northern coastal area of British Columbia. Geological Survey of Canada, unpublished contractor report, [3] Ocean Science and Productivity (OSAP) Division archive, IOS, data for Queen Charlotte Basin area (water depth < 400 m)..

RECOMMENDATIONS

•A guideline document must be prepared for the establishment of benchmarks for petroleum biomarkers and metals to permit source identification of acute and chronic emissions from an offshore oil and gas industry in B.C.

•Guidelines should refer to, but not be limited to, the petroleum compounds and chemical elements discussed in this report.

•Guidelines should recognise that source identification methods are evolving and that new or refined procedures are likely to be available when work begins to establish petroleum benchmarks.

RECOMMENDATIONS (cont'd)

•Preparation of adequate benchmarks will require advance survey work to characterise the existing petroleum signatures in sediments, seawater and biota in areas where new drilling is likely.

•Baseline studies must be completed and the benchmark profiles must be established prior to the commencement of drilling activities.

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Zn	0.26-69000 µg/L	No data	4-500 ng/L
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Ra-228	0.6-1509 pCi/L	No data	0.006 pCi/L

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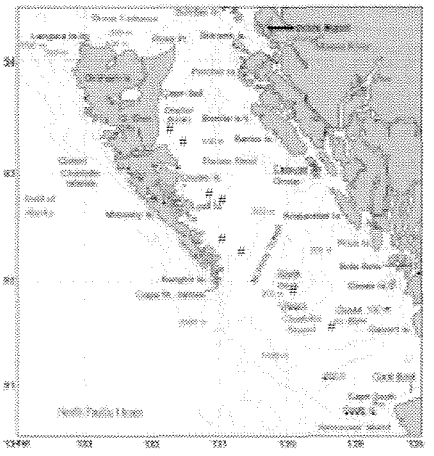


Figure 1. Geographical region of Queen Charlotte Assessment area

Table 3. Typical tricyclic terpanes, hopanes, steranes and diasteranes determined for petroleum fingerprinting and fate and effects studies

Terpanes	Steranes and Diasteranes[1]
Tricyclic Terpanes	*Steranes (m/z 217)*
C_{19}-Tricyclic terpane	20S-13β(H),17α(H)-Cholestane (diasterane)
C_{20}-Tricyclic terpane	20R-13β(H),17α(H)-Cholestane (diasterane)
C_{23}-Tricyclic terpane	20S-5α(H),14α(H),17α(H)-Cholestane
C_{24}-Tricyclic terpane	20R-5α(H),14β(H),17β(H)-Cholestane
Diagenetic (Rearranged) Hopanes	24-ethyl-20S-13β(H),17α(H)-Cholestane (diasterane)
18α(H)-22,29,30-Trisnorneohopane (Ts)	20S-5α(H),14β(H),17β(H)-Cholestane
17α(H)-22,29,30-Trisnorhopane (Tm)	20R-5α(H),14α(H),17α(H)-Cholestane
17α(H),18α(H),21β(H)-28,30-bisnorhopane	24-ethyl-20R-13β(H),17α(H)-Cholestane (diasterane)
17α(H),21β(H)-30-Norhopane	24-methyl-20R-5α(H),14α(H),17α(H)-Cholestane
17β(H),21α(H)-30-Normoretane	24-ethyl-20S-5α(H),14α(H),17α(H)-Cholestane
17α(H),21β(H)-Hopane	24-ethyl-20R-5α(H),14β(H),17β(H)-Cholestane
22S and 22R-17α(H),21β(H)-Homohopane	24-ethyl-20S-5α(H),14β(H),17β(H)-Cholestane
22S and 22R-17α(H),21β(H)-Bishomohopane	24-ethyl-20R-5α(H),14α(H),17α(H)-Cholestane
22S and 22R-17α(H),21β(H)-Trishomohopane	24-propyl-20S-5α(H),14α(H),17α(H)-Cholestane
Biogenic Hopanes	24-propyl-20R-5α(H),14β(H),17β(H)-Cholestane
22,29,30-Trisnorhop-17(21)-ene	24-propyl-20S-5α(H),14β(H),17β(H)-Cholestane
17β(H)-22,29,30-Trisnorhopane	24-propyl-20R-5α(H),14α(H),17α(H)-Cholestane
Neohop-13(18)-ene	*Steranes (m/z 218)*
17β(H),21β(H)-30-Norhopane	20R-5α(H),14β(H),17β(H)-Cholestane
17β(H),21β(H)-Hopane	20S-5α(H),14β(H),17β(H)-Cholestane
Diploptene (hop-22(29)-ene)	24-methyl-20R-5α(H),14β(H),17β(H)-Cholestane
Terpanes	24-methyl-20S-5α(H),14β(H),17β(H)-Cholestane
18α(H)-Oleanane	24-ethyl-20R-5α(H),14β(H),17β(H)-Cholestane
	24-ethyl-20S-5α(H),14β(H),17β(H)-Cholestane
	24-propyl-20R-5α(H),14β(H),17β(H)-Cholestane
	24-propyl-20S-5α(H),14β(H),17β(H)-Cholestane

[1] These steranes are only a subset of the compounds present, but they are the compounds that in most cases can be reliably quantified without GC-MS-MS. Sterane derivatives such as the monoaromatic and triaromatic steranes (m/z 253 and 231, respectively) also can be valuable petroleum source indicators particularly for biodegraded oils

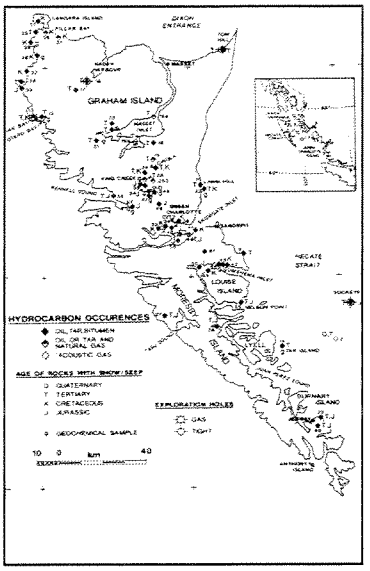


Figure 8. Hydrocarbon Occurrences, Queen Charlotte Islands (from Hamilton and Cameron *Bull. Can. Petrol. Geol.* 37:443-466 (1989))

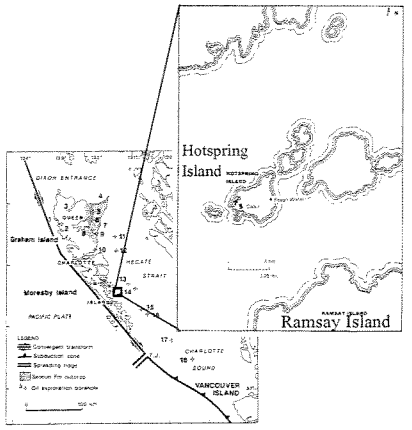


Figure 11. Location of hotsprings on Hotspring Island. (main from Whitticar, M.J. 2002. Appendix 6 *In:* British Columbia Offshore Hydrocarbon Development: appendices to the Report of the Scientific Review Panel. Ministry of Energy and Mines, Victoria, B.C., pp. 26-36. Insert from McDonald et al. 1978. "Hotsprings of Western Canada: A Complete Guide.")

Discussion

To establish a sufficiently robust model to detect hydrocarbons originating from drilling activity, a solid data baseline of water, sediments and possibly the surface is required. Since many compounds are correlated, a significant amount of data can be provided by a smaller subset of samples. When running GCMS analysis, it is not much more work or expense to obtain information on all resolved components rather than a limited number of target compounds.

Tar balls are found on beaches on Queen Charlotte Island. Balls are mobile and come from local seeps, ships, or seeps located elsewhere (e.g., Alaska). Information on currents would be useful in determining their possible sources.

To date, many of the previous test wells in BC were dry, but there were traces of hydrocarbons in the strata. The figure of 10 billion barrels has been used based on potential play analysis. Note that at the present time there are no "reserves", only potential. The estimate could now differ from that of the late 1980s as the potential was based on information available at that time. When the seismics from Shell and Chevron are compared, one realises that interpretation depends on the analysis techniques used. There is lots of room for 14 dry holes.

Before drilling on the East Coast, industry did extensive baseline work on hydrocarbons and metals for monitoring programs. It is up to DFO and other agencies to provide guidelines. There is a need to establish the biological relevance of the compounds sampled and to provide really good fingerprints for source information.

Background Physical Oceanography of Seas Surrounding the Queen Charlotte Islands

B. Crawford

Fisheries and Oceans Canada

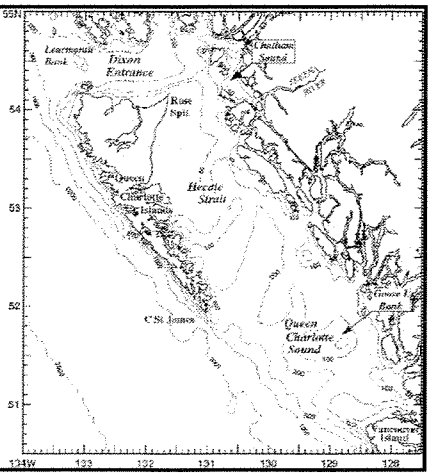
Background Physical Oceanography of Seas Surrounding the Queen Charlotte Islands

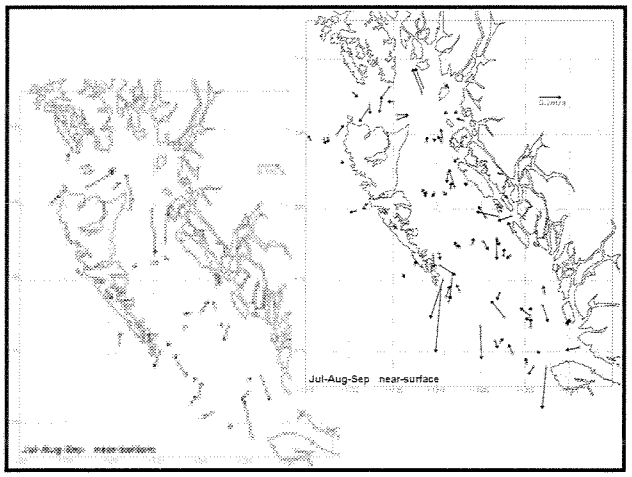
William Crawford,
Institute of Ocean Sciences, Fisheries and Oceans Canada,
P.O. Box 6000, Sidney, B.C. V8L 4B2

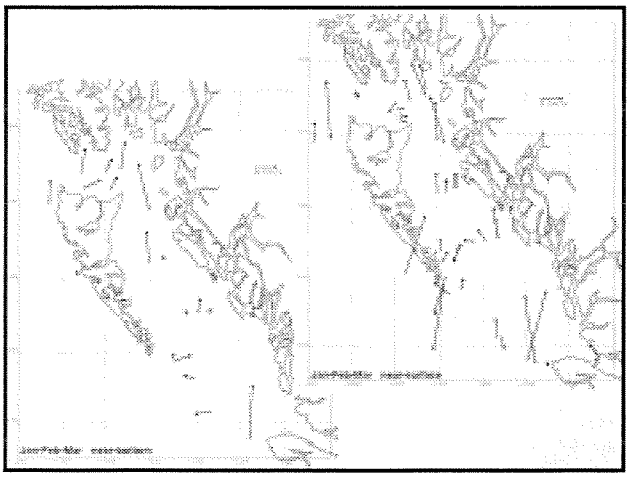
Except for the shallow waters of Goose Island Bank, and of Dogfish Banks to the east of Graham Island, most waters are deeper than 100 m.

Most significant hydro-carbon leases lie along west side of Hecate Strait, but there are also leases in other regions of Hecate Strait, as well as in Dixon Entrance and NE shelf waters of Queen Charlotte Islands.

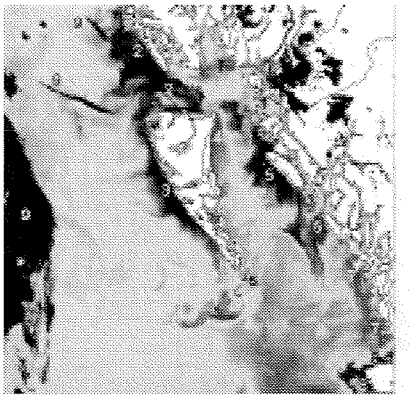
The Canadian-US border runs from headland to headland across northern Dixon Entrance.



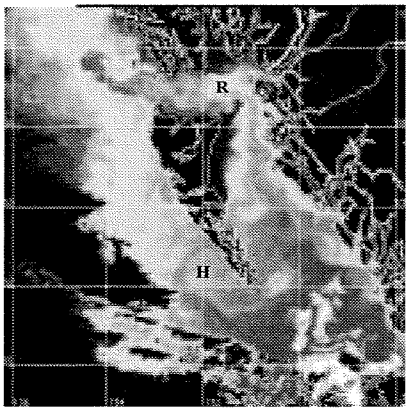




Sea surface Temperature patterns, 24 July 1994, as measured by satellite



Sea surface Temperature patterns, 25 December 1996, as measured by satellite



R is a Rose Spit Eddy (cyclonic).

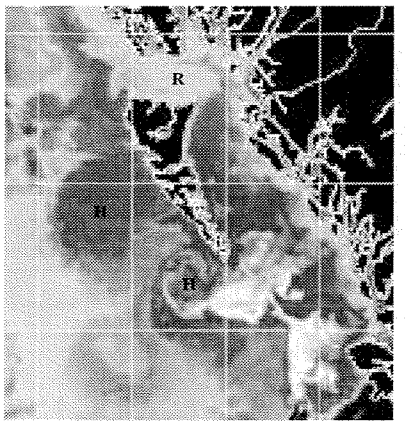
H is a Haida Eddy (anti-cyclonic).

4 February 1998

Features denoted H are Haida eddies. These two merged in June 1998 and drifted through the Gulf of Alaska for 2 years.

Haida eddies in a typical winter carry westward into the gulf about 1/3 of northward winter oceanic heat flow, and 1/4 of winter fresh water input to continental shelf.

Feature R is a Rose Spit Eddy.



Simulation of sea level anomalies in northern BC waters from January to June in a typical year.
E. Di Lorenzo, Scripps Inst. Oceanogr + M.G. G. Foreman, W.R. Crawford, Inst. Ocean Sci.

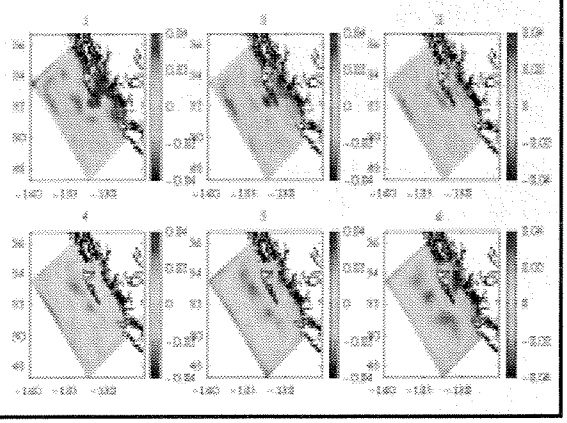
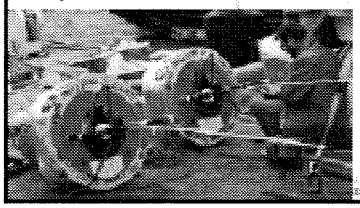
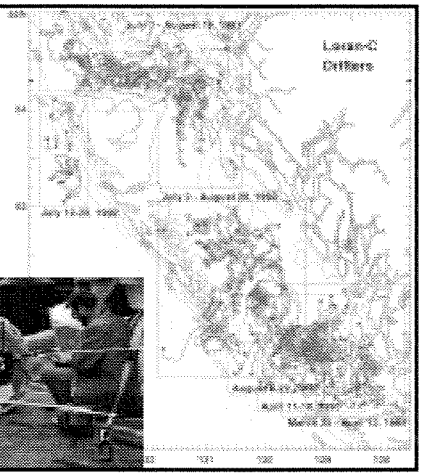


Figure at right displays tracks of near-surface Loran-C drifters for summers of 1990 to 1995, used to compute characteristics of semi-diurnal tidal currents in these waters, following method of Crawford and Cherniawsky (1998).

Below: photo of two drifters.



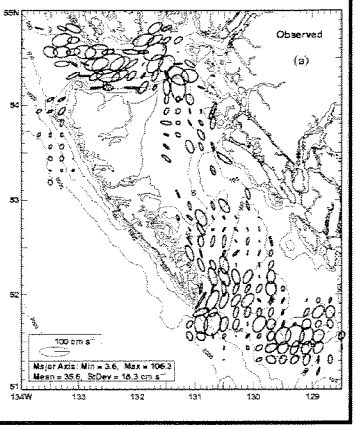


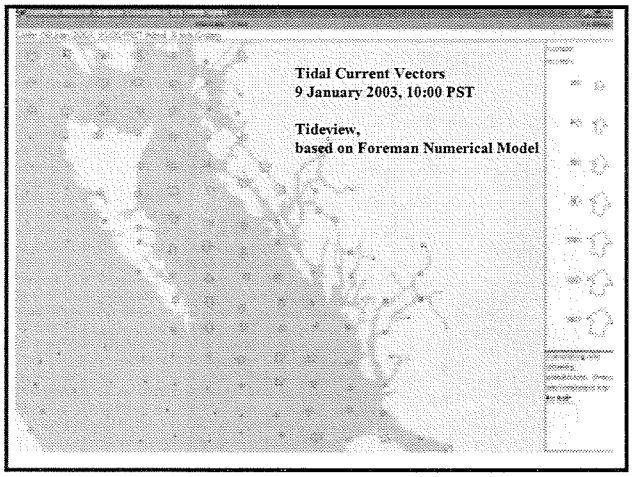
At Right:

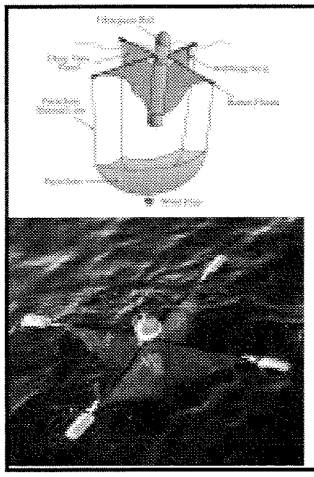
Semi-diurnal, tidal current ellipses computed from drifter tracks on days of observations. Size of ellipses depends on time during spring-neap cycle as well as on geographical position.

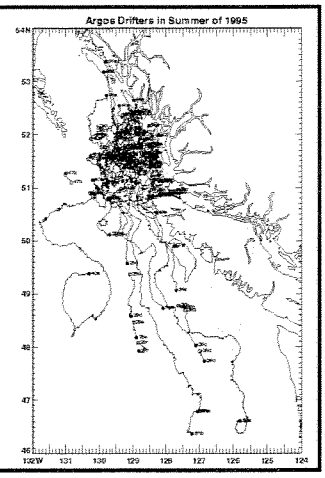
All vectors rotate clockwise, except those represented by shaded ellipses.

Models by Patrick Cummins and Michael Foreman, both at IOS in DFO, reproduced these currents reasonably well, except in Dixon Entrance where internal tides are strong.

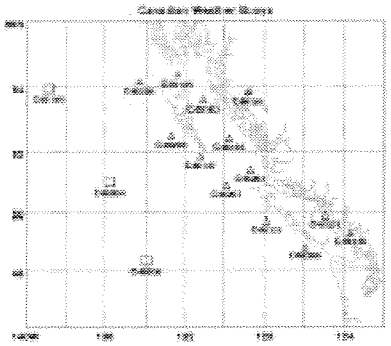








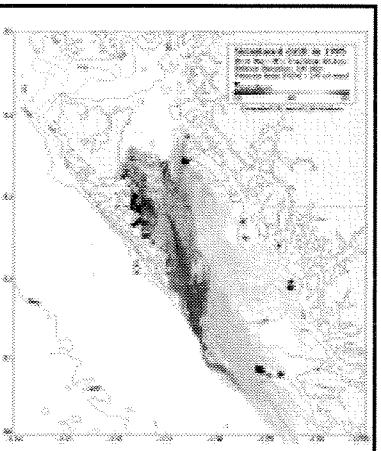
The West Coast array of weather buoys is maintained by Environment Canada and Fisheries and Oceans Canada, measuring wind, air pressure, sea temperature, air temperature, waves.



A constant 2% of wind speed was applied to floating material drift, to account for motion over the surface currents simulated by Princeton Ocean Model (POM), developed by Patrick Cummins of IOS/DFO. The simu-lation computed no oil spreading due to ocean turbulence, natural oil spreading over water, evaporation, or other fates noted earlier.

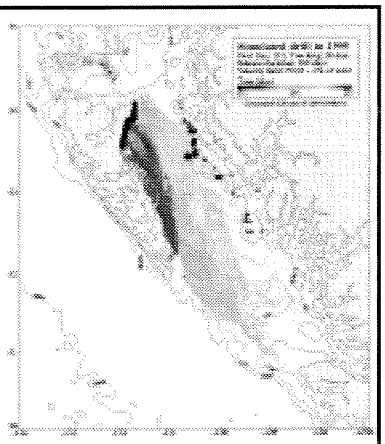
The simulation represents late spring and summer conditions only. Summer winds tend to blow from the North or Northwest, and account for the generally southward drift in these simulations. Winter winds blow strongest from the South or Southeast, and will push oil more toward the north, and toward the eastern shore. Such winds generally begin to blow strongly in mid-October.

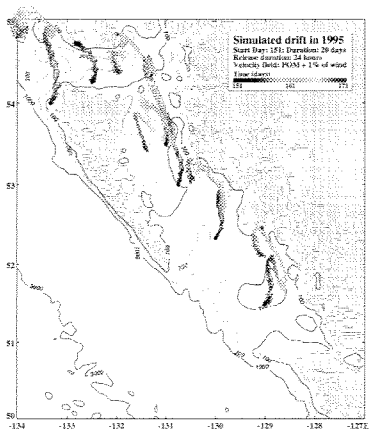
The POM simulation does not represent motion due to surface waves near shore. Nor does it include sea breeze effects near shore. Therefore, it may predict too little oil encountering shore.



POM currents do not include as yet the surface ocean motion due to outflow of fresh and brackish waters from the mainland inlets along the east side of Hecate Strait and Queen Charlotte Sound. Upwelling processes and tidal mixing combine here to produce a complicated pattern of plumes in summer that require additional study. Winter surface currents here are even less well known.

Many of these processes are forced by small-scale winds near shore that are poorly measured, if at all. Better current simulations will require development of accurate mesoscale meteorological models of the region. Most particles stay in coastal waters for at least twenty days, and can spread over considerable extent during this time. There is strong variability from one twenty day period to the next. Most regions of Hecate Strait and Queen Charlotte Sound seem to be vulnerable.

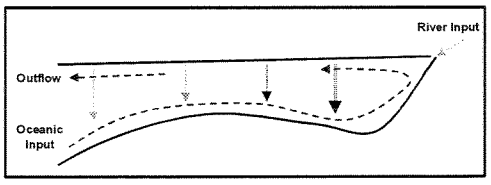




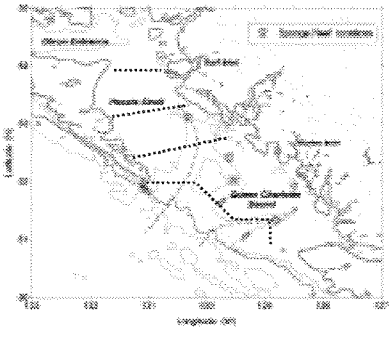
Similar plot to previous figures, but with a 15 wind drift rather than a 2% wind drift.

Particles are released at many points for 24 hours only, on 31 May, 1995, and then tracked for 20 days.

Estuarine Circulation plus Vertical Particle Fluxes

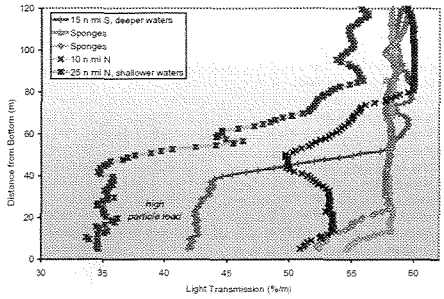


The entire coastal inlet, Hecate Strait area can be viewed as an extended estuary, beginning where river discharge creates an outflow surface current which empties into the North Pacific Ocean. Estuaries are effective nutrient traps.



A major route for inflow waters which replace salt in inlets is through troughs. During summer upwelling, this inflow helps flush inlet basins.

Sampling over several years in Rivers Inlet shows that seasonal upwelling affects the salinity, oxygen and nutrient concentration of waters below the mixed layer.



Sponge reefs occupy a very selective habitat in Hecate Strait and Queen Charlotte Sound. They require high silicate concentrations for their spicules and rocky bottom to grow on. A recent survey (summer 2002) suggest they are efficient particle trappers, growing on the mound of detritus that results. Some reef mounds are 30 m high.

RECOMMENDATIONS
Environmental Effects, physical oceanography and meteorology.

Adapted from manuscript:
Modelling Oceanic Fates of Oil, Drilling Muds and Produced Water from the Offshore Oil and Gas Industry, with Application to British Columbia, submitted to *Pacific Science Advisory Review Committee*, DFO, December 2002, by Crawford, Cretney, Cherniawsky, and Hannah.

Several numerical, hydrodynamical, ocean models have been applied to the Queen Charlotte Assessment Region, and evaluated with oceanographic observations. PERD funding for this program ceased in 1996. Faster computers and improved hydrodynamical models have been developed recently, and funding should be provided to apply these improvements to the Queen Charlotte Assessment Region. Upgrades will improve simulations of tidal currents, bottom currents, rate of exchange of water between basins, penetration of contaminants into inlets, channels and bays, and the potential of oil to sink below surface brackish water and penetrate into inlets below surface.

Additional observations are required to provide better model simulations of ocean currents and drift. A program to measure winter currents using surface drifters will help determine the penetration of oil-on-surface into inlets. Better measurement of mid-depth and bottom currents and sediment motion will help determine transport of produced water or drilling muds away from well heads, and toward sensitive habitat, fjords, and unique biological features such as sponge reefs.

Since completion of the PERD-funded field program in 1996, there have been major inter-annual changes in seawater properties in the northeast Pacific Ocean, that appear to have impacted fish stocks in the Queen Charlotte Assessment Region, but these changes of seawater characteristics, such as temperature, nutrient composition, and ocean currents, were poorly measured in these local waters.

Funding should be provided for an ongoing program to determine inter-annual changes in the seawater properties of the Queen Charlotte Assessment Region, and their impact on the ecology and fish stocks. Without such research, it will be difficult to distinguish changes in ecology due to contaminants from changes due to climate variability and change.

These changes in climate may have impacted wave climate as well. (More on this from Diane Masson next.)

Accurate wind measurements and forecasts are essential for spill prediction and risk assessment. The present set of Canadian Weather Buoys on the Pacific Coast should be considered a minimum number for data input to oil spill models and for evaluation of regions-at-risk.

Canadian Weather Buoys measure winds in mid-strait, and do not provide needed information on near-shore winds that will influence adhesion of oil on the beaches, or into inlets and narrow channels. Real-time winds as measured at Canadian Weather Buoys and forecast winds based on regional, high resolution models must be available to assess potential oil spill motion and hence vulnerability of sensitive regions.

Environmental Factors
Present models under-report tidal currents and extreme non-tidal currents. Additional effort will be needed to determine ocean currents for engineering applications, and to develop operational models of currents. Existing numerical models of tidal heights in these waters are accurate. Additional work may be needed to predict non-tidal sea level changes. Waves will be discussed by Diane Masson next.

Discussion

Near bottom current measurements are based on a standard measurement of 15 m off the bottom. If information on currents 2 m off the bottom is required, it is uncertain how relevant these measurements would be. A published paper by Crawford shows the strongest bottom current vector measured at each site. Shipboard ADCP is useful but there is a need to unscramble the tidal and non-tidal currents. The disadvantage is that it takes work to get it into a useable form.

El Niño is a winter phenomenon that really changes winter currents but only in years of very strong El Niño. Significant events on the West Coast took place in 1982, 1983, 1997 and 1998. Alterations in productivity are caused by El Niño induced changes in water masses but there are other causes as well. The late 1990s were poor years for biological productivity on the shelf even in those years that were not El Niño years.

On the East Coast, current measurements on the slope were important, as this was one of the primary areas for exploration. Few measurements have been taken on the West Coast slope. There are measurements at three points on the slope along the West Coast of the Queen Charlotte Islands. These measurements showed internal tides. On the West Coast, there is concern about locating moorings on the slope because it is steep.

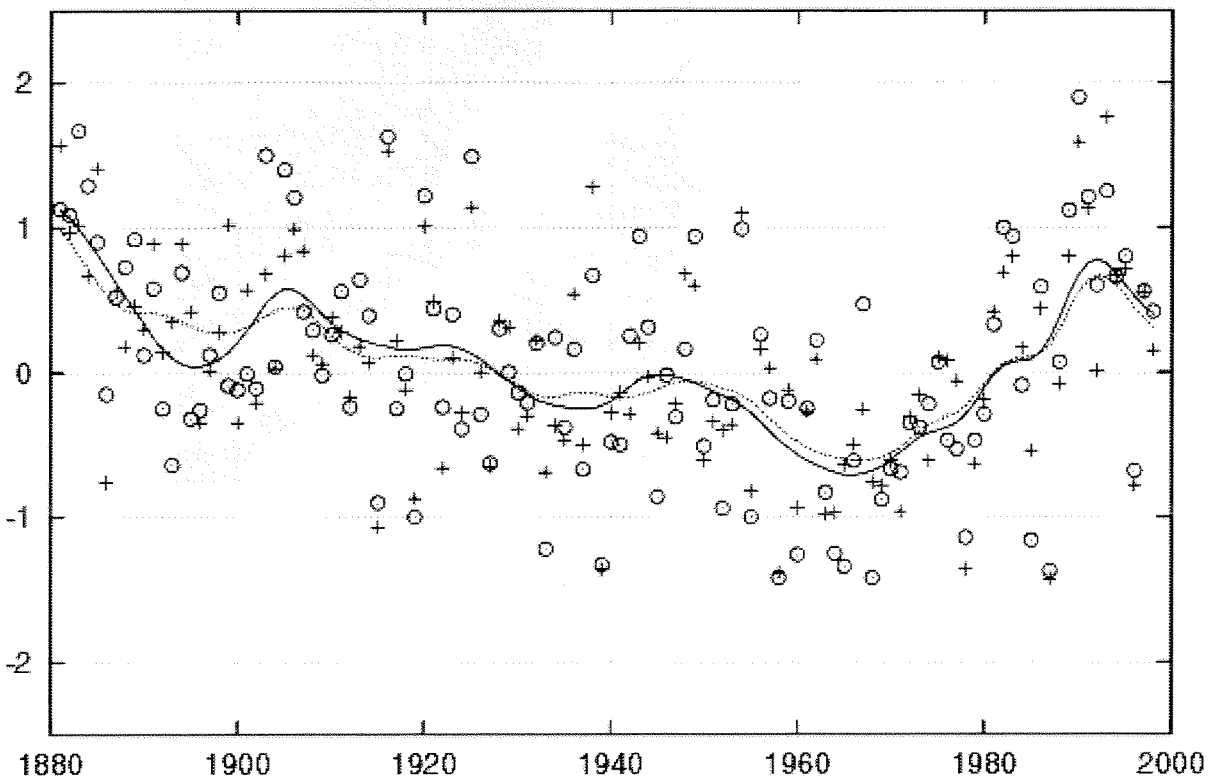
West Coast Offshore Oil and Gas Workshop: PERD

West Coast Waves

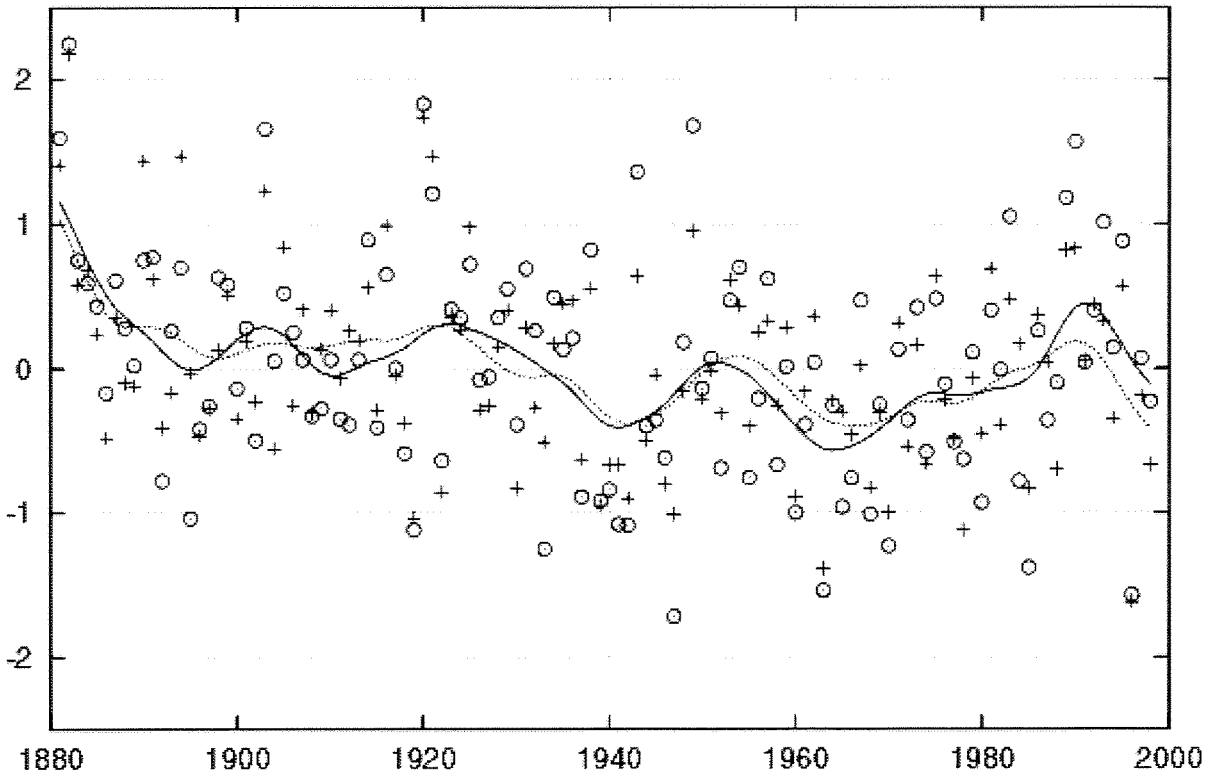
D. Masson

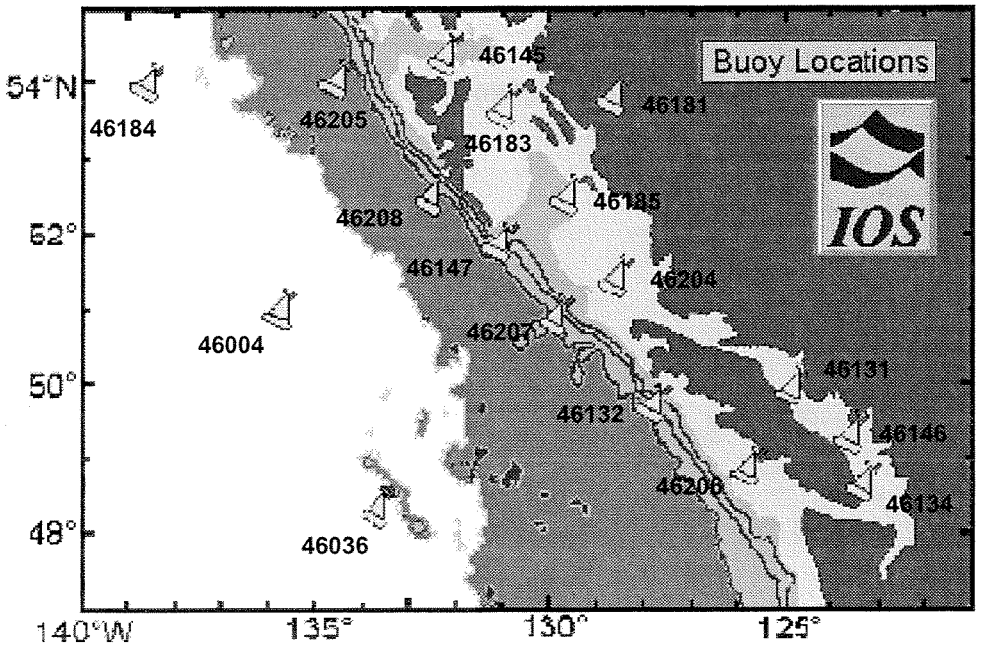
Fisheries and Oceans Canada

British Isles, North Sea, Norwegian Sea, 1881-1998



Scandinavia, Finland, Baltic Sea, 1881-1998





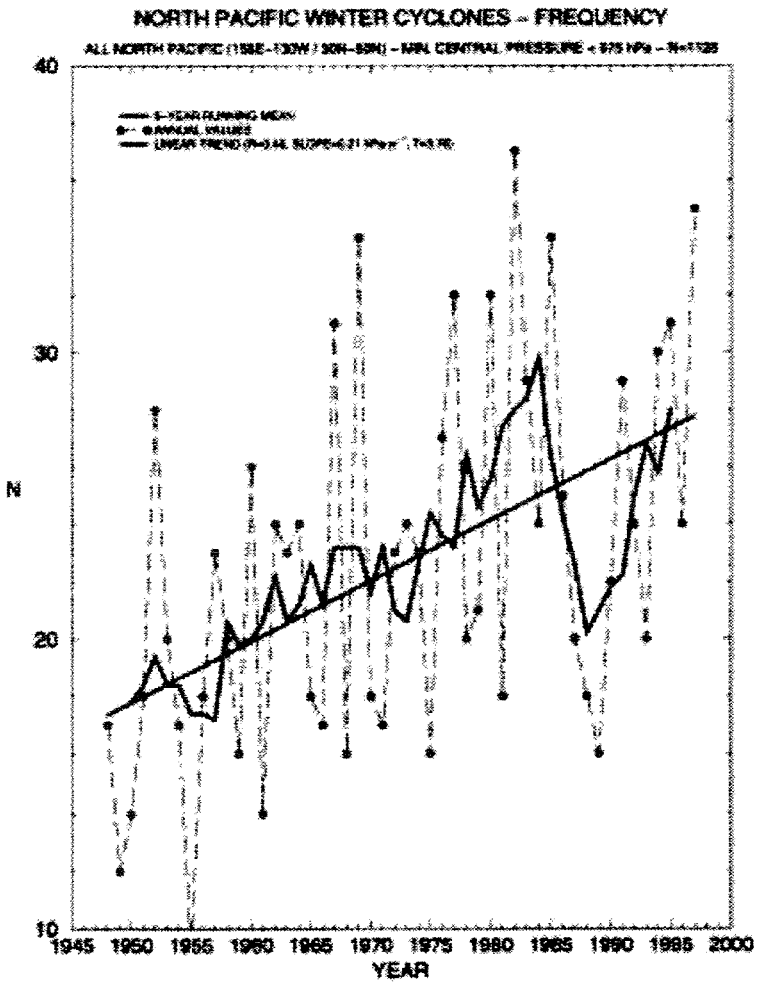
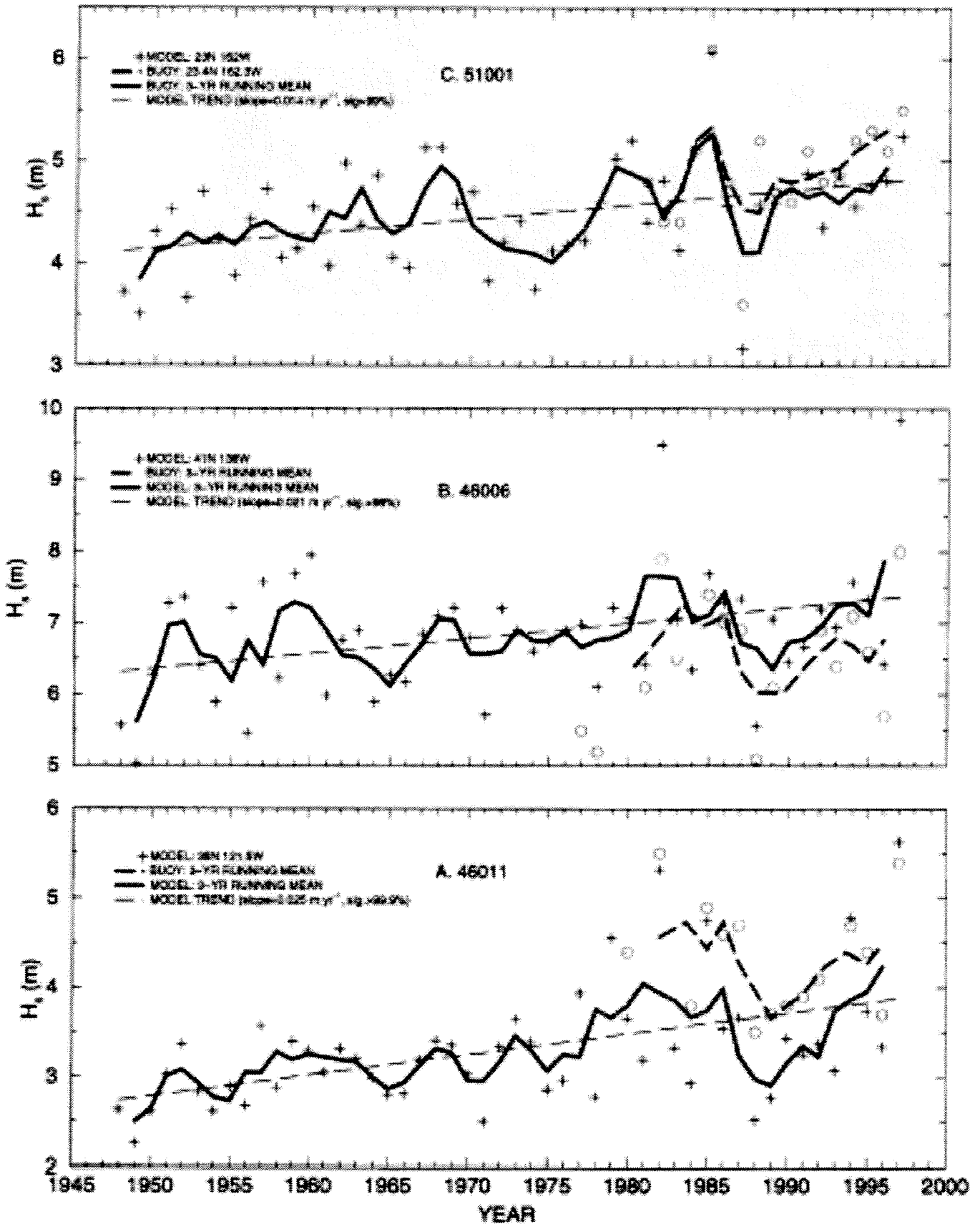


Fig 2. (a) Time series of winter (Dec-Mar) counts of North Pacific cyclones with minimum central pressure less than 975 hPa. The curves show the raw data (dashed line with circles), the 5-yr running average (heavy solid line) and the linear trend.


C. 51001
B. 46006
A. 46011
H_s (m)
YEAR
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000

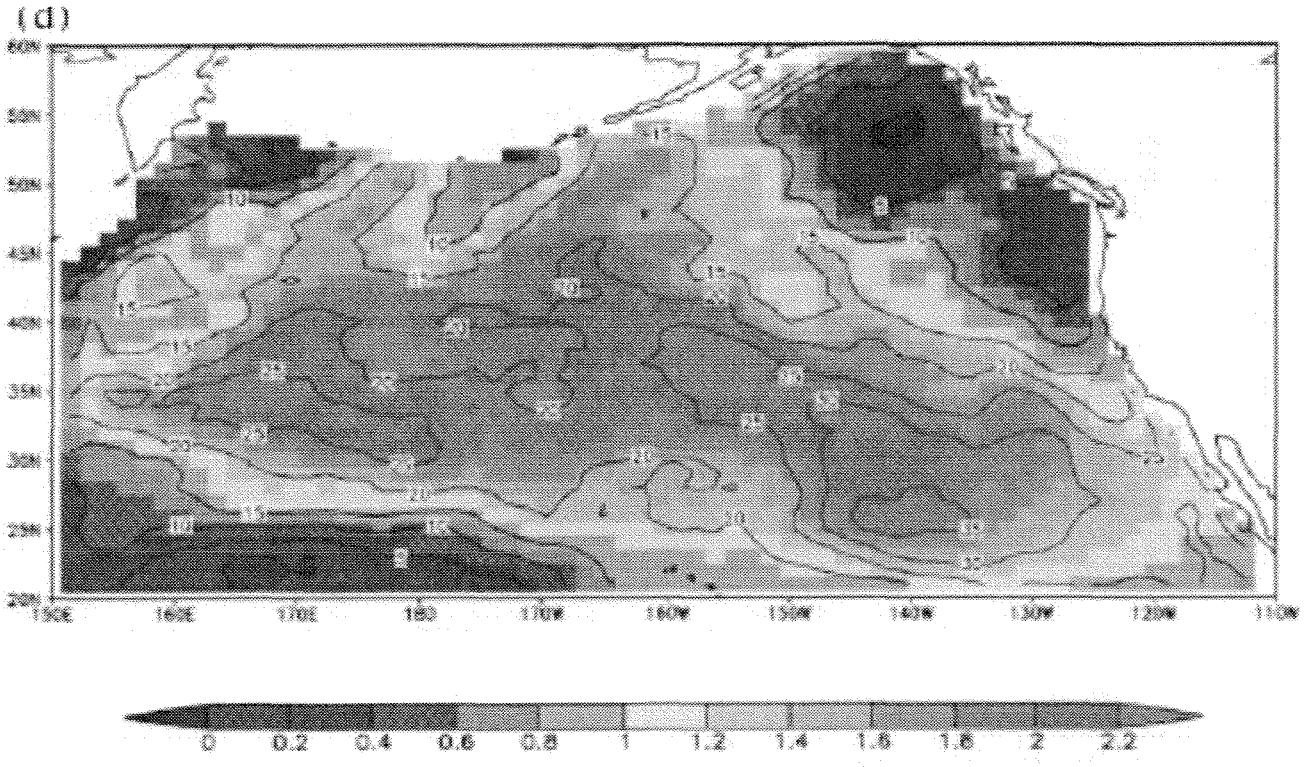


Fig. 11. Dec-Mar 95th percentile significant wave heights for NOAA buoys (a) 46011, (b) 46006, and (c) 51001; heavy solid and dashed lines are 3-yr running averages from hindcast and measured data, respectively; symbols are unsmoothed values; thin dashed lines show linear trends in hindcast data. For years with observations, the plotted data are for contemporaneous 3-hourly data. Buoy 46011 is located at 34.9°N, 120.9 °W; the model grid point is at 35 °N,120 °W. Buoy 46006 is located at 40.9 °N, 137.5 °W; model data grid point is at 41 °N, 138 °W; Buoy 51001 is located at 23.4N, 162.3 ° W; model data grid point is at 23 °N, 162 °W. See Fig. 12a for locations. (d) Trends in hindcast Dec-Mar 99th percentile H_s [m(50yr)$^{-1}$]. Black contour lines show trend expressed as a fraction of the long-term mean.

Discussion

It is important to design a wave climate study with as long a sampling period as possible. Earlier determinations of maximum wave height were not based on the correct wave buoy algorithm. Also, computation of the maximum wave was wrong: calculating the maximum wave as twice the maximum positive amplitude, rather than true peak to trough.

A Pacific study using the Wave Watch 3 Model off California was shown to give poor results for the total wave condition because it was tuned to emphasise swell. There is a recent study on the Northern Hemisphere with both a Pacific component and an Atlantic component that also has a subsequent Atlantic component based on hind cast. These two studies are relevant to the West Coast.

The 1992 maximum 100-year wave within Hecate Strait and Queen Charlotte Sound was 25 m, but this does not include the shallow water effect so there is a margin of error.

An Overview of West Coast Marine Geoscience

V. Barrie

Natural Resources Canada

ISSUES

- Queen Charlotte Basin Oil and Gas
- Fisheries and Habitat
- Sponge Reefs - Protection of Unique Habitat
- Wind Farms
- Marine Minerals and Aggregates

Data Base:

- Data Collection Prior to 1990
- Poor Navigation (pre GPS)
- Geophysical Coverage
  - 10 - 15 km line spacing
- Sediment Samples
  - grab samples and cores
- Multibeam Coverage
  - one line

NRCan - GSC

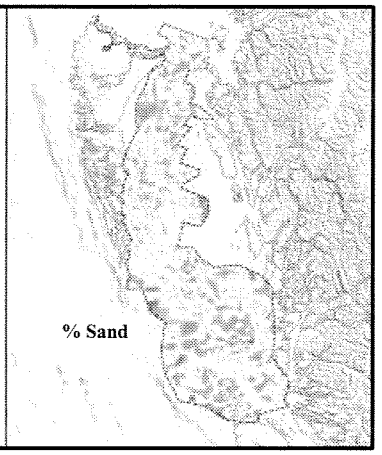
Geoscience for Ocean Management Program

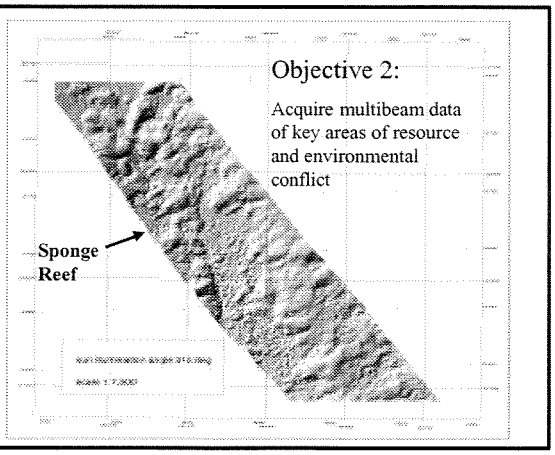
Objective:

To provide the geoscientific knowledge necessary for effective decision-making on competing resource management issues in the Queen Charlotte Basin

Objective 1:

Generate web accessible, national standard maps of geohazards, habitat, and surficial geology





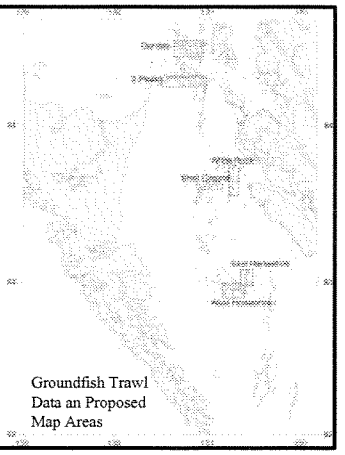
Objective 2:

Acquire multibeam data of key areas of resource and environmental conflict

Objective 3:

Map and delineate the benthic habitats for sustainable fisheries and provide knowledge for the establishment of marine protected areas

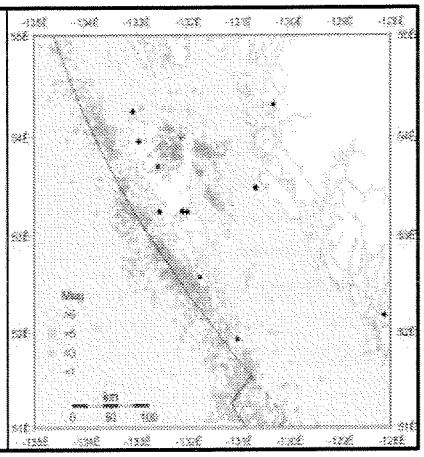
Hecate Strait Ecosystem Project - DFO, NRCan, UBC, UVic



Objective 4:

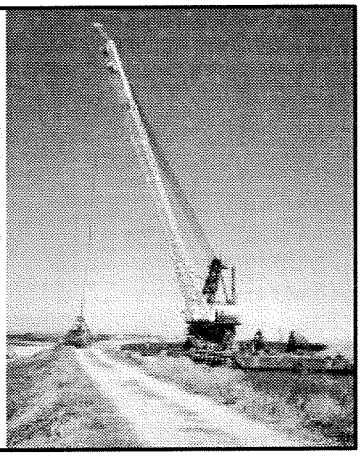
Determine the seafloor expression and risk assessment of marine geohazards

- Slope Stability
- Shallow Gas
- Sediment Mobility
- Sedimentary Bedforms
- Boulder Fields

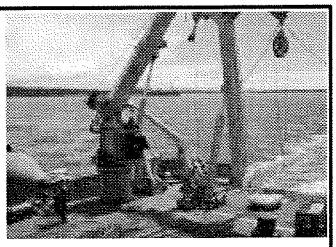


Objective 6:

Assess the impacts that extraction of aggregates will have on the environment and fisheries habitat



Summary:



- Queen Charlotte Basin is know to the world for two conflicting characteristics, 1) world heritage site for cultural, biological and geological ecosystem, and 2) resource wealth in fishing, potential hydrocarbons, wind power and precious and industrial minerals.
- What is needed is a integrated Ocean Management Program to balance the competing demands of renewable and non-renewable resources with conservation through digitally accessible outputs.
- Role for PERD?

Discussion

The 70% referred to in the presentation is based on the area mapped. If a multibeam survey program goes ahead, it will delineate the boundaries of features.

Earthquakes and Earthquake Hazard in the Queen Charlotte Islands Region

G. Rogers

Natural Resources Canada

Earthquakes and Earthquake Hazard in the Queen Charlotte Islands Region

Garry Rogers
Natural Resources Canada
Geological Survey of Canada
Pacific Geoscience Centre
Sidney, B.C. V8L 4B2

INTRODUCTION

The Queen Charlotte Islands region has a high rate of earthquake activity. The Queen Charlotte fault, which runs along the west coast of the Islands, is one of the world's major tectonic plate boundaries. Like the San Andreas fault in California, it accommodates motion between the Pacific plate and the North American plate. Canada's largest historic earthquake, a magnitude 8.1 event in 1949, occurred along this fault. It is a feature that has ongoing earthquake activity and people in the region feel earthquakes regularly. There was much concern expressed about earthquake hazard during the West Coast Offshore Environmental Review Panel hearings in 1983

PREVIOUS OERD PROJECT IN THE REGION

From the mid 1980s to mid 1990s OERD funded the operation of a seismograph network in the Queen Charlotte Island region. This snapshot of earthquake activity at a lower magnitude threshold revealed a more extensive seismicity pattern than that associated directly with the Queen Charlotte fault. In particular, considerable earthquake activity occurs east of the fault, on Graham Island and in Hecate Strait. A magnitude 5.3 earthquake occurred in Hecate Strait in 1990. None of the earthquake activity appears to be associated with mapped faults. Focal mechanism studies reveal that the earthquakes are occurring on a wide range of fault orientations, but are being activated by a consistent north-northeast compressional stress field.

The network also revealed that most of the earthquake activity in the vicinity of the Queen Charlotte fault, is not on the fault itself, but in a band of activity on either side of the fault. The earthquake rate is also not uniform along the fault, with some areas having much higher activity than others.

EARTHQUAKE HAZARD ASSESSMENT

An earthquake hazard assessment for the region exists in the form of national earthquake hazard maps that are part of the National Building Code of Canada. The Geological Survey of Canada is responsible for producing these maps. The main tool used in producing the hazard maps is the statistical analysis of past earthquake activity. The basic assumption in applying the statistical analysis is that earthquake occurrence is a random process that is constant though time. In assessing hazard in the vicinity of a major plate boundary this assumption breaks down because of the varying rate of activity in between very large earthquakes. Other techniques such as crustal deformation measurements or paleoseismic investigations are required to get a robust assessment of the earthquake hazard.

UNSOLVED PROBLEMS

There is a need to determine where and when large earthquakes are likely to occur in this region, to calculate the expected level and duration of shaking, and to determine if and where local tsunamis may be generated.

The present motion between the Pacific and North American plates is not currently parallel to the Queen Charlotte fault. How the component of plate motion perpendicular to the fault is accommodated is not clear. In 2001 a magnitude 6.3 pure thrust earthquake occurred in the vicinity of the Queen Charlotte fault, generating a small tsunami. Whether this tectonic setting can produce large megathrust earthquakes and accompanying large tsunamis is a subject that needs investigation. Initial GPS measurements in the region show significant strain rates but are not yet dense enough to resolve the accumulating strain field.

ADDRESSING THE UNSOLVED PROBLEMS

What is required to arrive at a robust estimate of earthquake hazard in the Queen Charlotte Islands region is to gather the new data necessary to make the estimate. This would involve supplementing the current seismic network in the region, making it similar to the OERD funded network that operated from the mid 1980s to the mid 1990s. In addition, deploying a modern GPS network would allow the necessary crustal strain measurements for earthquake hazard assessment to be made. A minimum of 3 years of GPS monitoring is required to assess the nature of crustal strain.

Discussion

While the risks associated with floating platforms are less than with fixed platforms, risks still exist. Risk is associated with blowouts, pipeline ruptures and the associated structures or infrastructure used to exploit the resource. There are standards in the world for fixed and floating platforms. The Canadian Standards Association has a specific document to deal with fixed structures. Along with development comes a whole range of physical structures (e.g., a gas pipeline in the Queen Charlotte Islands where not a lot of data exist).

In regards to the costs of re-installing and maintaining a network to collect seismic data; once the system is installed the annual cost is a few ten thousand dollars plus the cost of analysis. The capital cost for the GPS sites is $50-60K per installation. The seismic data comes out via satellite link. One satellite link in the Queen Charlottes costs about $5K per year plus some cost to service the equipment. Depending on how quickly one proceeds to expand the system, the costs ranges from a few hundred thousand dollars, plus ongoing expenses, plus some people, which increases the cost to $800K, including people for analysis work if it were done in two years. The existing system uses partnerships; for example, the local school board provides Internet access, the Coast Guard provides free sites and facilities and helicopter support and the University provides graduate students.

An Ecosystem Approach to Fisheries Management in Hecate Strait

A. Sinclair

Fisheries and Oceans Canada

Slide 1

An Ecosystem Approach to Fisheries Management in Hecate Strait

•To expand our knowledge of factors affecting the productivity of marine fish and invertebrate communities in Hecate Strait and Queen Charlotte Sound

•To develop new stock assessment techniques that incorporate ecosystem considerations and can be introduced into the mainstream advisory process

•DFO SSF main funding source

•http://www-sci.pac.dfo-mpo.gc.ca/sa-hecate/

Slide 2

Project Team

- DFO Pacific Biological Station (Nanaimo, BC)
  - Jeff Fargo
  - Alan Sinclair
  - Ian Perry
  - Jake Schweigert
- DFO Institute of Ocean Studies (Sidney, BC)
  - Bill Crawford
  - Mike Foreman
- NRCan Pacific Geoscience Centre (Sidney, BC)
  - Vaughn Barry
  - Kim Conway
- U Victoria
  - Ross Chapman
- UBC Fisheries Centre (Vancouver, BC)
  - Carl Walters
  - Villy Christensen
- Simon Fraser University
  - Sean Cox
- Independent Scientists
  - Dan Ware
  - Don McQueen
  - Isobel Pearsall
  - Brian Bornhold
  - Al Tyler

Slide 3

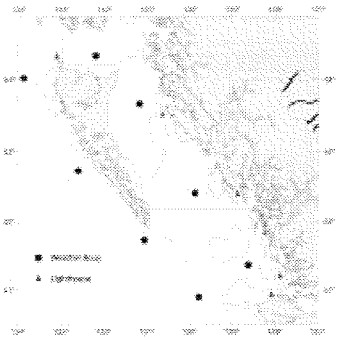
Mapping of Marine Populations and Their Habitat

- Locate all legacy data on marine populations and their habitats in Hecate Strait, improving data accessibility, develop analytical tools
- Principle data sources
  - Physical oceanography of Hecate Strait and surrounding area
  - Surficial geology and bathymetry
  - Groundfish bottom trawl surveys
  - Commercial fishery catch and effort
  - Biological samples from research surveys and commercial fisheries
- Test for species and community associations with depth, temperature, and bottom type
- Describe seasonal and ontogenetic changes in habitat association
- Test for changes in distribution relative to abundance and environmental conditions.

Slide 4

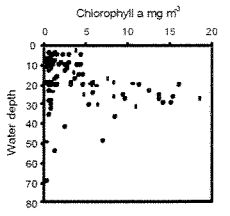
Ocean Climate

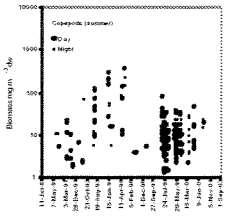
- Temperature
- Salinity
- Wind
- Precipitation
- Sunlight
- Circulation
  - Tides
  - Sea Level
  - Eddies
- Upwelling
- Mixed Layer Depth



Slide 5

Primary and Secondary Production

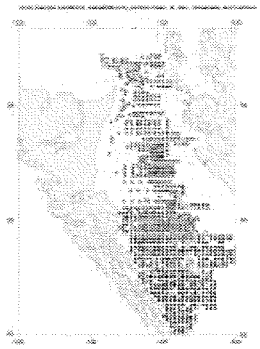




Slide 6

Surficial Geology

- Sidescan sonar
- Huntec seismic
- QTC view
- Grab samples
- ROV video



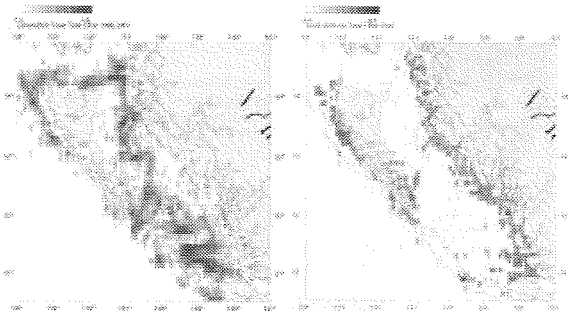
Slide 7

Fish and Invertebrate Populations

- Fisheries
- Species distributions
- Diversity
- Marine communities

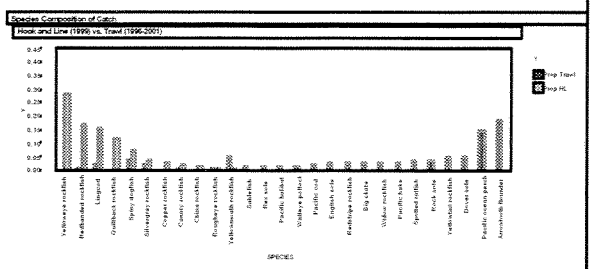
Slide 8

Distribution of Trawl and Hook / Line Fisheries



Slide 9

Species Composition of Trawl and Hook / Line Catches



Slide 10

Hook and Line Habitat

- Rocky and bolder substrate
- Epifauna plentiful and diverse
- Common fish species are rockfish

Slide 11

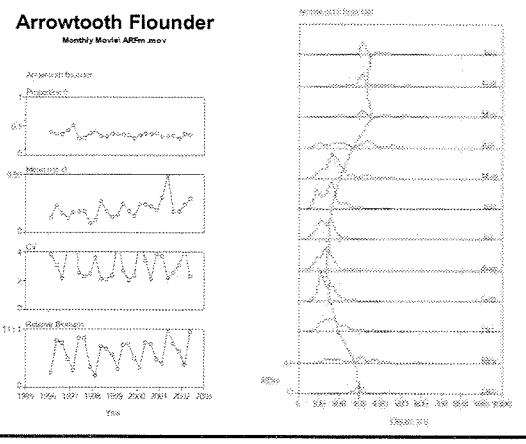
Trawl Habitat

- Substrate smooth sand and mud
- Limited epifaunal diversity
- Common fish species flatfish and gadoids

Slide 12

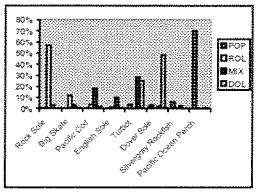
Arrowtooth Flounder

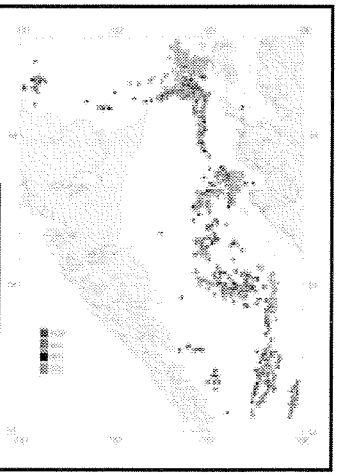
Monthly Movie ARFm.mov



Slide 13

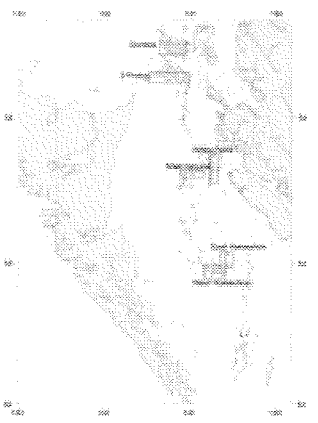
Trawl Fishery Aggregates: Locations





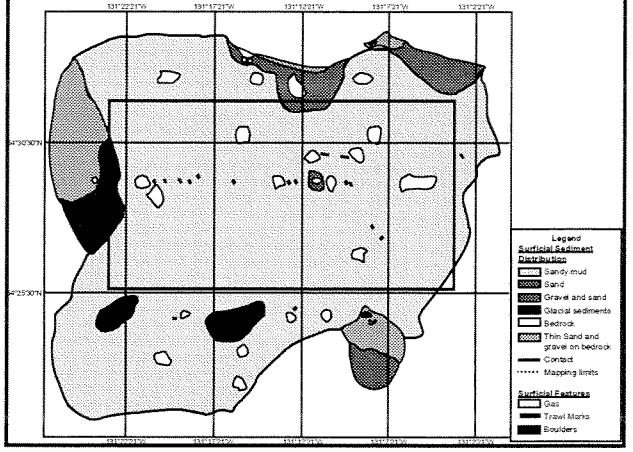
Slide 14

Surficial Geology / Fish Habitat Pilot Areas



Slide 15

Surficial Sediment Distribution and Surficial Features: Dundas Area



Slide 16

Biological Interactions / Environmental Effects

- Ecosystem Modeling
  - Mass-balanced snapshot of the resources in the ecosystem (Ecopath)
  - Ecosystem simulation (Ecosim)
    - Model calibration with observed time series of catch, fishing effort and survey indices.
    - Investigate biological interactions (top-down) and physical forcing (bottom-up)
- Multispecies Production
- MSVPA
- Test individual species stock recruitment and competition dynamics

Slide 17

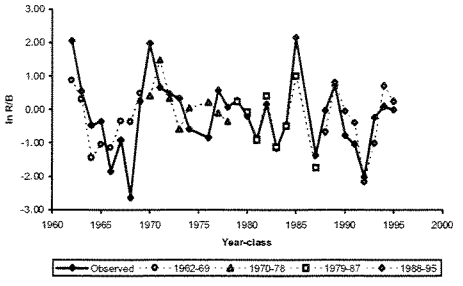
Tyler and Crawford (CJFAS 1991) Revisited

- Hecate Strait Pacific cod stock recruitment relationship with environmental and biological covariates.
  - S: Cod spawning biomass
  - L: Circulation using Sea Level as Indicator of circulation
  - T: Temperature at Bonilla lighthouse
  - J: Herring as prey for juvenile cod (age 0+1)
  - P: Herring as prey for spawners (biomass in year prior to spawning)
- Relationship fit using data from 1962 - 1986.
- Recruitment for 1987-1995 predicted using model parameters and independent variables.

Slide 18

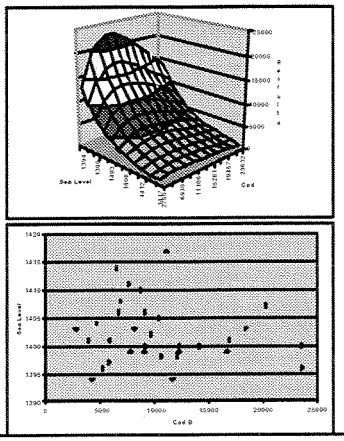
Best Model included Sea Level and Pacific Cod biomass:

Confirmed original conclusions



Slide 19

Predicted Effect of Sea Level Variation on Cod Recruitment



Slide 20

Summary

- The Hecate Strait Ecosystem Project is integrating oceanographic, biological and geological data
- Developing ecosystem based models at two levels
  - Fisheries production in relation to physical forcing and biological interactions
  - Fisheries production and distribution in relation to habitat
- The project is finishing its second of three years

Discussion

All of the observers have been on trawlers. The hook and line data comes from the fishing logbooks. Observers are being deployed on hook and line boats now but at a very low level, about 5%. They are much smaller vessels and harder to get people aboard. The bycatch of 200 species has been from trawlers, the numbers are much lower in the hook and line fishery. Previously, observers were deployed on trawl fleets, and about 80 species were reported. Now with observers to record bycatch and discards, the number is about 200. Discards would account for about 120 species.

In terms of sponge reefs, starting in 1999, observers began to record the occurrence of reef material in the nets so the information is in the observer data. Data agree well with known reef locations. The amount of fishing effort over reefs is very low; the reef material clutters up the nets. In 1999, there was a voluntary closure on the part of the trawl fishery to avoid fishing in the area designated as having living sponge reefs and there was an effort to avoid them. There was evidence from our trip in June that there had been some recent fishing over the reefs so there is now a regulated closure for trawlers.

Modelling that associates fish distribution and habitat has some obvious links to oil and gas development, transportation and decisions on where to site infrastructure. Rockfish populations along reefs live for something like 50 to 100 years. Rockfish, which are susceptible to fishing, have low productivity rates and are susceptible to oil spills, so there is interest in gaining more knowledge about what is going on in those areas. Ecosystem modelling is oriented towards physical forcing factors, such as temperature, that affect primary production. How to introduce perturbations that may stem from oil and gas development is not entirely clear. There are a few animals that are very important in the food chain about which we know very little. For example, the sandlance is the most important fish species in the diet of certain other fish, yet we know very little about its distribution and basic biology other than that it spends time burrowing in the sand. The sandlance could be sensitive to seismic exploration and various other activities. It would be important to devote time to this and the work would also contribute to delineating sensitive areas.

There are other fisheries beside trawl and hook and line, for example, crab are trapped on Dogfish Bank to the east of the Charlottes. Production spikes have been noted and it is desirable to obtain more information about what drives their dynamics. There is also a shrimp fishery and a large herring fishery in spawning beds in coves along the coast of the Charlottes and the mainland.

Information has been submitted in a paper to the Fisheries Oceanography Journal and was presented at the last Fisheries Oceanography Committee (FOC) meeting in March (2002).

Plankton in Queen Charlotte Sd/Hecate Strait: What's Known (and What Isn't)

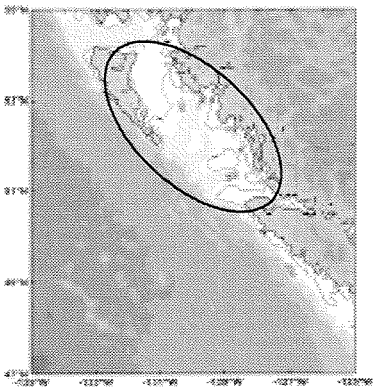
D. Mackas

Fisheries and Oceans Canada

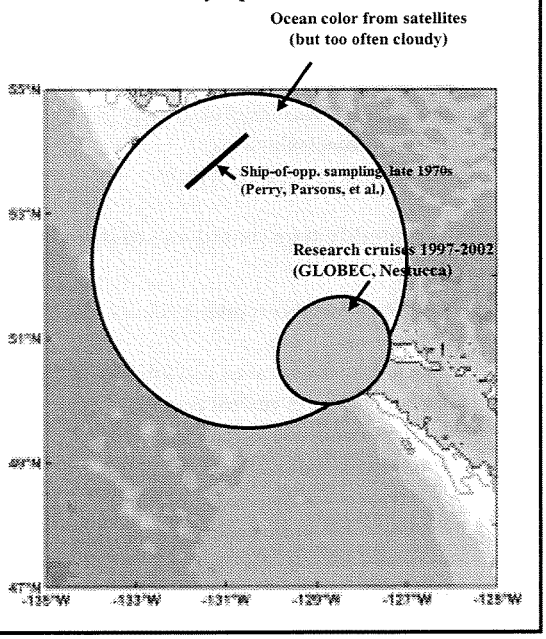
West Coast Offshore Oil & Gas Workshop

Plankton in Queen Charlotte Sd/Hecate Strait: What's Known (and What Isn't)

D. Mackas
Institute of Ocean Sciences
Fisheries & Oceans Canada.

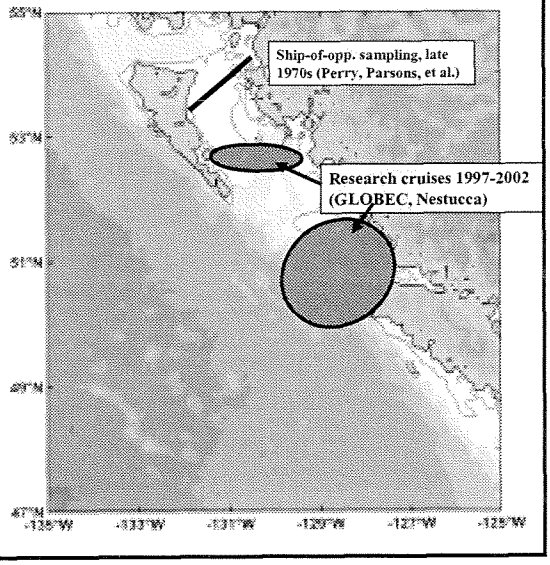


Spatial coverage of recent sampling: Phytoplankton



Spatial coverage of recent sampling:

Zooplankton



What's known:

- Main nutrient supply mechanisms (tidal mixing, estuarine circulation, upwelling)
- Rough seasonal cycles of phytoplankton and zooplankton biomass & productivity
- Dominant zooplankton taxa
- Dominant prey-predator links??

What's probably true (based on studies elsewhere):

- Transfers to higher trophic levels are highly localised
- Trophic 'hot spots' often spatially associated with bathymetry & current patterns
- Large seasonal and interannual variability
- Direct acute toxic effects of oil on plankton are fairly small BUT
- Plankton 'hot spots' are aggregation foci for more vulnerable predators (seabirds, fish, mammals)

What's NOT known:

- **Location and variability of trophic 'hot spots'**
- **Interannual variability of plankton productivity and community composition (except in southern QCS)**
- **Other details of spatial distributions (both vertical and horizontal), and implications for transfer of contaminants**
- **Open water occurrence of harmful algal blooms**

West Coast Weather and Climate Issues

L. Neil
Environment Canada

West Coast Weather and Climate Issues

West Coast Oil & Gas Workshop

Institute of Ocean Sciences, 2003

Laurie Neil

EC/MSC/PYR

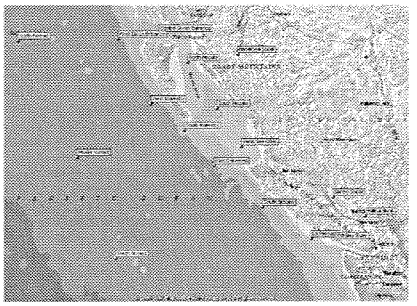
The Provincial Panel Report...

- did not adequately address weather and climate concerns
  - no meteorologists or climatologists on review panel or list of consultants
  - little acknowledgement of weather-related issues
  - panel members unaware of current climate change concerns

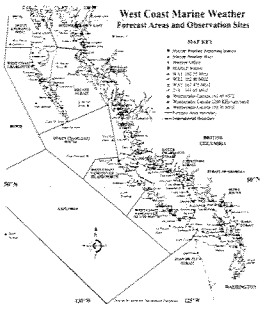
What we know...

- winds/wave data from 16 marine buoys since ~ 1990
- a few shore stations have provided hourly records for past 50-60 years
- lighthouse reports every 3 hours, daylight only

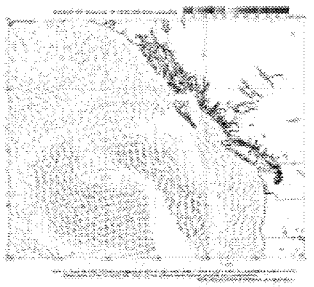
Marine Buoys...



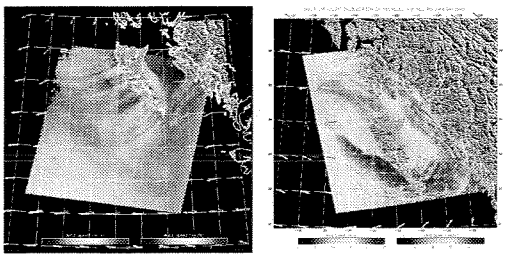
Other Observing Sites and Forecast Regions...



Satellite-derived winds...



More Satellite Derived Winds..



Other assets…

- computing power
  - improved global and regional models
  - ensembles
  - 2.5 km mesoscale models
- radars
- ACARS/AMDAR
- lightning detection

Recent losses…

- high-quality manned observations
  - lighthouses, climate, others
- Automated Shipboard Aerological Program (ASAP)
- reduced MAREP program
- R&D capability has been impacted

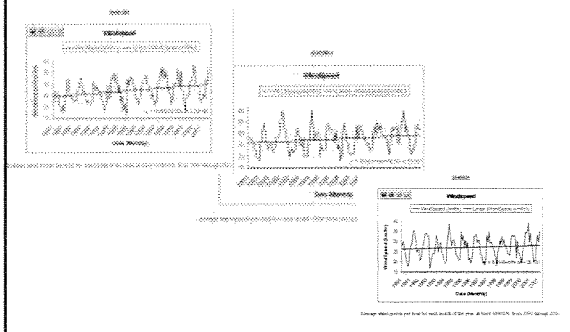
Knowledge gaps…

- incomplete knowledge of wind speeds and wave heights
  - current buoys measure only to 31 m
  - rogue waves
  - wind reports from coastal locations are sparse, sometimes unrepresentative

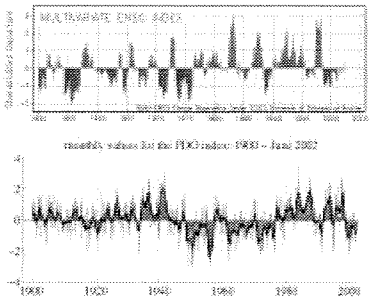
Knowledge gaps con't: Climate change…

- Allan & Komer reported that 100 year significant wave off Washington coast increased from 10 to 16 m because of intense storms in the 1990's
  - what could be its cause?
  - what is the geographical distribution?

Knowledge gaps con't: Wind speed trends…



Knowledge gaps: ENSO and PDO



Knowledge gaps, con't... Pacific Data Void

- lack of ***mid-tropospheric data***
- paper by Mass & McMurdie in upcoming issue of Weather & Forecasting shows that:
  - from Oct. 99 – Mar. 02, 48 hr fcst errors > 10 mb occur 10 – 15 times/year, avg. position error 475 km

  and errors > 15 mb occur 3 – 4 times/year
- 24 hr fcsts often bad as well

Knowledge gaps... Mesoscale wind variations

- lack of coastal radar data
- synthetic aperture radar data not fully utilized

Other Knowledge gaps...

- storm durations
  - for mitigation, rescue
- frequency of repeat storms (esp. marine bombs)
- mesoscale wind variations
- predictability
  - compared to other locations

Projects to address knowledge gaps...

- Frequencies and durations of extreme weather conditions
  - incl. magnitudes and return periods of high winds, snow and icing events, heavy rain, waterspouts and lightning
  - includes GIS-based reference system for identifying locations with high probabilities of hazardous conditions
  - utilize SAR winds
  - investigation of explosive cyclogenesis (marine bombs)
  - assessment of models

Projects to address knowledge gaps, con't...

- Predictability and the ***Pacific Data Void***
  - paucity of "upstream" mid-tropospheric data
  - analysis of forecasting skill along BC coast
  - study of innovative observation technologies
    - THORpex
      - aerosondes
      - dropsondes
      - rocketsondes
    - radar

Projects to address knowledge gaps, con't...

- Wind climatology for marine areas
  - develop high-resolution wind climatology of development areas
  - utilize SAR imagery
  - also emphasis on outflow plumes from coastal inlets

Projects to address knowledge gaps, con't...

- Periodic and Long Term Climate Change
  - suggestions of accelerated climate change
    - e.g. Allen & Komar (2002)
  - analysis of relationships between ENSO, PDO and climate change
  - investigation into changing synoptic patterns/storm tracks
  - experiments with numerical climate models (e.g. Canada's Global Climate Change model)

Projects to address knowledge gaps, con't...

- wave spectra and height maxima
  - study data from 16 marine buoys
- improved instrumentation on buoys
- special emphasis on rogue waves
- wave modeling with emphasis on rapid wave growth near frontal systems (IOS)

Projects to address knowledge gaps, con't...

- Establish Chair for Applied Meteorological Impacts at UBC
  - facilitate incorporation of academic research into marine R&D efforts
  - build on *CICMMH* initiatives, also links to UNBC
  - focus academic attention/research on offshore hydrocarbon issues

Conclusions

- Pacific is largest ocean in the world
- deep lows, explosive cyclogenesis are common
- multiple wave trains, swells from NW thru S plus wind waves
- storm force arctic outflow through inlets extends offshore
  - structural and vessel icing
- unique predictability issues due to data void
- weather issues should not be downplayed!

Winds whack Westshore

Discussion

Stating the largest wave and highest wind velocity in Hecate Strait is difficult. Maximum waves may be higher than we think. There is a problem of buoys truncating the maximum height, and shallow water effects increase the wave height. There are very strong tidal currents in and around the Charlottes, which steepen the waves if not increase their height. Maximum waves are probably 20-33 m. Every year there are hurricane-force winds in coastal waters.

So far, shallow water effects are not included in the operational wave forecasts. The Marine Forecast Centre in Vancouver currently provides forecasts. We are just now becoming aware of mesoscale variations in the wind field and their effects on waves. There are dramatic wave effects near shore with a lot of variation and these are not included in the operational forecast. Forecasters in Vancouver use the Global Environmental Model but are not constrained to this model; they will use whatever model they feel is best. One wave model, used by the Forecast Production Assistant group, makes use of CMC grid-point initialisation data over the entire Pacific. Currently, they use the wave model guidance that comes from CMC in addition to the atmospheric guidance. They are not using their own wave model as they were five or six years ago.

The new buoy sensor package using completely new technology is much better. They will be located on the Great Lakes, Lake Winnipeg, and one each on the East and West coasts.

Pacific storms are just as strong as those on the East coast. There have been a couple of huge storms in the Pacific. Small storms can be tighter but more devastating than the bigger ones. The dynamics of storm development on the two coasts are quite different. On the East Coast the Gulf Stream is a source of heat and moisture. On the West Coast there are other factors such as stronger jet streams and more fetch.

It is suggested that since each rig has 24-hour forecasting in terms of hazards, the data gap mostly relates to shipping routes and the fishing industry. On the East Coast there are 24-hour forecasts as well as private forecasting services. This would likely happen on the West Coast as well. Just because rigs are floating and are large does not mean they are not affected by bad weather and seas. Floating drilling platforms stay put and sustain whatever comes at them. We do not know some of the conditions we need to know for engineering design purposes. Our period of record is too short and we may have climate change altering the picture. A lot of projects are proposed to address these issues. The more activity you have offshore, whether it is oil drilling or fishing or something else, it is subject to weather and waves and that is where the issues lie.

Offshore Oil and Gas and the UNBC Northern Coastal Information and Research Program (NCIRP)

N. Dale

University of Northern British Columbia

Offshore Oil and Gas and the UNBC Northern Coastal Information and Research Program (NCIRP)

Presentation to West Coast Offshore Oil and Gas Workshop, January 8-10, 2003
By Norman Dale

Northern Land Use Institute
University of Northern British Columbia

UNBC/NCIRP is not alone!

- "Academia"
  - —Coasts Under Stress (UVIC & others)
  - —Royal Roads University
  - —SFU Centre for Coastal Studies
  - —UBC Fisheries Centre Hecate Strait work
  - —Northwest Community College
- New BC Offshore Oil and Gas Team
- PERD, COOGER, WED

Beginnings

New wave of interest in Northwestern BC in offshore development – mid to late 1990s

- **Offshore Oil & Gas Task Force**
- **Independent Scientific Review Panel**

Task Force says ...

- **make efforts to work cooperatively with First Nations to address economic & environmental concerns...encourage their involvement in the process of economic renewal.**
- **Exploration and development need to be based on sound science and careful risk-benefit analysis.**
- **Assurances needed that healthy fisheries /tourism industries can operate alongside offshore oil & gas development.**
- **Do assessment of benefits and costs to local communities.**

Scientific Panel says...

- **Gain significantly higher understanding of sea-bottom &sub-surface conditions of the BC offshore**
- **Establish comprehensive pre-perturbation baseline data on biota, including life-cycle histories and habitats...(so as to) understand and assess which aspects of the marine ecosystem might be most at risk**
- **Complete critical data-bases**
- **Do thorough cost-benefit analysis ... to assess alternative strategies for uses of the marine ecosystem**
- **Set guidelines on impacts of seismic exploration on the ecosystem;**
- **Design a strategy for the training of British Columbians for the wide range of job requirements and opportunities**

Northern Coastal Information and Research Program (NCIRP)

Inaugurated with a grant from BC to the UNBC

- **$2 million , starting May 2002**
- **"to advance the state of scientific and other knowledge related to offshore oil and gas"**

Program Goal:

To provide information and share knowledge that will enable people, especially those along the north coast, to make more informed and knowledgeable decisions about their future with respect to offshore oil and gas by...

- **assembling and distributing information**
- **adding to knowledge through research and technical projects**
- **liaising with/ ENGAGING people, communities, agencies and organizations**

Program Design/Capacity/Management

- **Task assigned to Northern Land Use Institute – Dr. Alex Hawley, Director**
- **Conducted extensive liaison within communities and w. government and university expertise**
- **Completed and posted work plan Sept. 2002 (http://www.unbc.ca/nlui/oog/pdf/work_plan.pdf that addresses conclusions & recommendations of Task Force & the Scientific Review Panel**
- **Took first cut at defining research needs**
- **Hired full time manager (Nov 02)**

Three Thematic Areas Within NCIRP

- **Data & Information**
- **Research**
- **Liaison**

Progress in Implementing 3 Program Themes:

1. Data and Information Management

- **what information is out there**
- **who has it**
- **how do we access it**
- **develop information and communication strategy and "home"**
- **coordinate with provincial and federal agencies**

Progress in Implementing Three Program Themes

2. Research

- **Based on broad input developed first cut list of potential research and technical projects in two categories:**
  - **Ecosystem function & environmental health**
  - **Socio-economic & community development**
- **Established Scientific and Technical Advisory Committee (STAC)**
- **Finalizing review/refinement of projects as of January 03**

Progress in Implementing 3 Program Themes

2. Research (cont'd)- Ecosystem function & environmental health

- Possible research topics -

- **North Coast Shoreline Habitat Atlas**
- **Ecological Impacts of Seismic Testing**
- **Biophysical Indicator System**
- **Identification of Marine Habitat Priority Areas**
- **Wind/Wave Hindcast Extremes**
- **Point Source Fluid Flow Model for Hecate Strait**
- **Effects of Lights and Flaring on Marine Birds**
- **Biological and Physical Impacts of Drilling Mud ...**

Progress in Implementing 3 Program Themes

2. Research (con't) Socio-economic & Community Sustainability

- Possible research topics -

- **Socioeconomic and Cultural Analyses of Different Marine Mgmt Strategies**
- **Employment and training possibilities and needs**
- **Cost-Benefit Analyses**
- **Infrastructure Study for Northwest Communities ...**

Progress in Implementing 3 Program Themes

2. Research (con't) submitted research concepts

- **Marine mammal impacts**
- **Mapping "productivity centers" for commercially significant fish & invertebrates**
- **Prepare Layman's Synthesis on oceanography**
- **Update coastal biophysical inventory**
- **Establish biological reference collections**
- **and more...**

Progress in Implementing 3 Program Themes

2. Research ... from here

- **STAC Review is completed**
- **Synthesize& probably amalgamate to manageable, affordable subset of projects in discussion with STAC and communities (see Theme 3)**
- **Assess what others are doing (as at this meeting) to *find collaborative opportunities* and avoid duplication**
- **Develop proposal call**
- **Launch projects (by March?)**

Progress in Implementing 3 Program Themes

3. Liaison and Engagement

- **We recognize that quality information and knowledge are not automatically used in decision-making**
- **We recognize that coastal communities are profoundly affected by and in touch with this issue and... know a lot!**
- **Building a network that we see as the COMMUNITY GUIDANCE SYSTEM to work along side researchers**
- **Community-based research to be explored as well as establishing presence on the coast, probably with other programs and institutions**

Contact:

Norman Dale

Program & Research Manager

Northern Coastal Information & Research Program

Phone: 250-960-6177

Email: dalen@unbc.ca

Website: www.unbc.ca/nlui/oog

Discussion

Integrating traditional ecological knowledge would have to happen in a number of ways. It has been suggested that the subject could be taken aside as a consultative research topic but experience working with First Nations goes against that because it tends to ghettoize the results. We are looking at over-layering the Terms of Reference on anything in the proposal to the fullest extent possible in a creative and sincere approach to incorporating traditional ecological knowledge. We need to recognise too that a lot of the traditional knowledge comes from fishermen and others who have lived on the coast for generations.

At the moment, there is no formal link to DFO's Marine Environmental Data Service (MEDS) database. It will be necessary to liaise with others who have database expertise. Those who have or use relevant databases as part of their research should get in touch with Norm Dale (UNBC – NCIRP).

There is no industry representative on the Advisory Committee of our program. The first task of the committee, review at a broad level, is drawing to a close. The committee is not closed at this point and the role of industries will be discussed.

$2 million exists in the program. Advice is to not get too many projects, a few amalgamated projects are preferred. Who does the work is not yet known, but it will certainly involve partnering with research groups that are non-consultant (e.g., government institutes and First Nations). Nothing is ruled out.

The Community Guidance System will develop community involvement in fine tuning research questions, in evolving project objectives, in reviewing work as it happens and finding other opportunities for community involvement. Researchers need advice and guidance based on local knowledge.

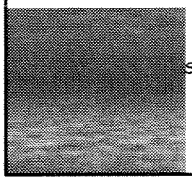
Priorities for Environmental Science

R. Creasey
Shell Canada Limited

West Coast Offshore

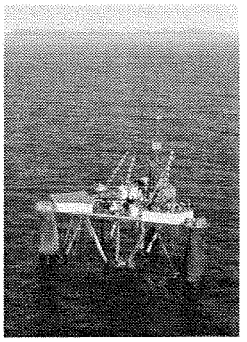
Priorities for Environmental Science

Presentation to the Fisheries and Oceans and Natural Resources Canada Workshop



Roger Creasey
Senior Environmental Advisor
Shell Canada Limited
Sidney B.C. January 2003

West Coast Offshore - A Unique Opportunity



- Basins largely untouched by modern exploration techniques are scarce globally.
- All the more so when they are sitting on the doorstep of the biggest natural gas market in the world.
- The West Coast must be explored carefully and with the utmost environmental protection
- We have some lead time to arrange studies and establish baseline data.
- However the lack of new data to evaluate prospectivity means that **uncertainty** in volume estimates is ***extremely high***

Key Issues

Who has the lead?

Industry • Hydrocarbon Prospectivity
Gov't/others • Clear Ownership, Access to Resources
↓ • Regulatory and Fiscal terms (economics)
Joint • Environmental Sensitivities
↓ • Access to Markets
↓ • Sustainable Development

History of Land Holdings on the West Coast

Shell/Chevron

1961: Shell - 5.6 mm ha

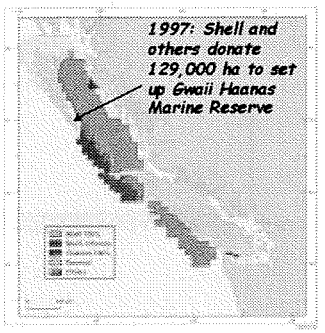
1970: Shell exploration halted

1971: farmout to Chevron *(not yet completed)*:
- Chevron acquires additional acreage, partial Shell backin

1972: moratorium

Other Industry

1982: **PetroCanada** acquired 3 blocks

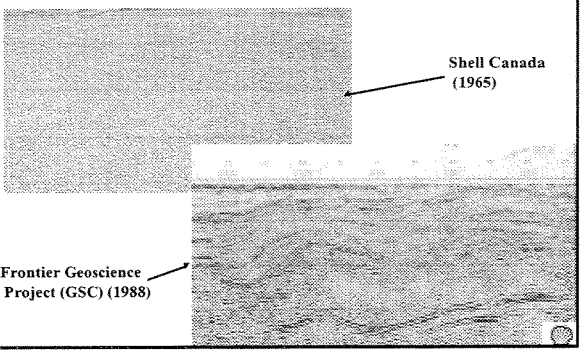


... HydrocarbonProspectivity

We Need: Early Seismic Coverage

- Huge uncertainty in resource potential offshore West Coast requires that we acquire a new subsurface data set
- ***pre-commitment regional*** seismic ***vs*** ***post-commitment detailed*** seismic
  - regional seismic surveys - "speculative" basis prior to land commitment? (open participation by industry)
  - detailed prospect surveys - done to fulfil E.L. work program commitments on a proprietary basis
- Drilling in a new area requires detailed seismic (thus, after the second seismic season)

Seismic data quality has a big impact on prospect identification...



...Environmental Sensitivities

We Need: Early Designation of Protected Areas

- Early initiation of environmental and baseline studies, and collation of existing information..
- Early stakeholder engagement and identification of protected areas.
- Examination and refinement of seismic and drilling buffer zones reflecting possible prospectivity and modern technology.

...Regulatory and Fiscal terms (1)

We Need: An Effective Regulatory Framework...

- Establishment of an effective regulatory framework
- Simple but effective rulebook ("Regulatory Roadmap")
- a "one-stop" window for regulatory approvals (minimize jurisdictional overlap and conflict)
- Smooth transition from Permits to E.L.'s. for existing landholders
- Clear environmental assessment process, focus Term of Reference (TOR)
- Key lessons available from East Coast experience (CAPP)
- Consider strategic EA of regional activity augmented with project EAs
- appointment of a dedicated provincial offshore oil and gas team to "work the issues" is a crucial first step in this... (but will require cooperation from the Government of Canada)

... Sustainable Development (1)

Implement Sustainable Development

- Using Shell Canada's policy as an example:
  - no harm to PEOPLE - skills of West Coast work force (risk phase vs project development phase)
  - protect the ENVIRONMENT and pursue the goal of prevention of pollution
  - use material and ENERGY efficiently to provide our products and services
  - DEVELOP energy resources in line with the above aims

... Sustainable Development (2)

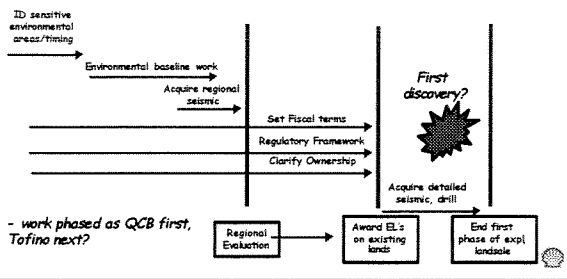
...Sustainable Development continued

- engage in stakeholder CONSULTATION
- play a leading role in PROMOTING best practice in our industry
- manage health, safety and SUSTAINABLE development as any other critical business activity
- implement action to conserve biodiversity
- promote a CULTURE in which all Shell employees share this commitment

Concurrent or Consecutive?

- many major pieces to the puzzle - regulatory, fiscal, environmental, technical, political and aboriginal.
  - If we wait for each to be concluded before the other starts we will be extend the timeline significantly (and it's already long!)
- At this early stage, let's do things in parallel where possible - land use and environmentally-based zoning, early seismic, land claims negotiations and regulatory/fiscal framework.
- This way, when a clear green light is given, the industry will be ready to move forward, in concert with the regulatory regime and the public.

Proposed Initial Steps to Facilitate West Coast Activity (concurrent "fastrack" model)



Some Specific Suggestions

- Ensure a fair transition from Exploration Permits to EL's
- allow early regional seismic, for a modern evaluation which will provide a solid basis for investment decisions.
- consider a phased area-based lifting of the moratorium - Queen Charlotte Basin first, Tofino Basin later?
- develop a **scientific** understanding of the implications of modern seismic and drilling on activity restrictions.
  - This is fairly well understood; what SPECIFICALLY needs to be done in light of the findings of the Strong Report?
- Let's think about how the government-stakeholder working relationship can be most efficiently coordinated.

Key Issues - Scorecard

Who has the lead?		***Present status***
Industry	• Hydrocarbon Prospectivity	?
Gov't/others	• Clear Ownership, Access to Resources	X
	• Regulatory and Fiscal terms (economics)	X
Joint	• Environmental Sensitivities	√ in part
	• Access to Markets	√ market health √ price/future ? route
	• Sustainable Development *(www.shell.ca)*	√√√

Key Messages to Take Away

- West Coast offshore is a potential opportunity for new basin natural gas (and perhaps oil?) exploration and development
  - but the degree of uncertainty re: resources is very high
- the issues/challenges are reasonably well understood; resolution of some issues may be more difficult
- stakeholders need to understand the process by which this opportunity will be moved forward
- opportunity to build upon our experience on the East Coast of Canada
- the establishment of a dedicated offshore oil and gas team is a crucial element of success, but will require some cooperation from the government of Canada to deliver
- Shell is the largest **BC** offshore landholder... and therefore a key stakeholder; will actively engage in the process once it is established, and effectively plan as that process takes shape from this point onward.

Discussion

For the oil and gas industry, "protected areas" generally refer to areas where no drilling will occur, but can also apply to areas where some seasonal or intensity restrictions apply. Industry is still learning how to deal with Marine Protected Areas (MPAs). The issue is what the impact would be, even if activity is short-term and localized. If there is an impact, it must be temporary if at all possible. Aesthetics of drill rigs in sensitive areas, for example near parks, is an issue.

The West Coast area is thought to have indications of natural gas. The environmental hazards from gas exploration and oil exploration differ. Gas pressures are sometimes higher and this has to be taken into account when designing the drilling system. Sour gas production wells demand more design and management considerations.

Gas fits into Shell's 50-year plan for getting prepared for the decarbonisation of fuels worldwide. Shell is in the wind power business and is moving toward becoming a hydrogen economy company.

Vessel traffic on the West Coast differs from the East Coast. For example, consider Hecate Strait versus Sable Island Bank or George's Bank. Hecate Strait is more constricted, may have different traffic patterns and has certain kinds of traffic such as barges and cruise ships. Factors reducing risk are the Notice to Mariners, better training and an exclusion zone around rigs.

Shell's participation in resolving environmental issues or assisting in the collection of baseline information, in some way prior to the lifting of the moratorium, is not out of the question. Shell has not been asked at this point and it must be recognised that it is harder to get approval before the moratorium is lifted on a purely business basis. A reasonable, pre-emptive project of some kind could be considered, something along the lines of collating known information or archiving. There are other companies that might wish to have a presence on the West Coast. It would be good to liase and to see industry people participate in a mini-version of this workshop.

If there were appreciable signs of hydrocarbons in the North that would stimulate interest, seismics could occur in both the Queen Charlotte and Tofino areas at the same time, although staging is a possibility, but there are other considerations such as parks being nearby. The whole issue of where and when exploration will be initiated is unanswered at the moment.

"Rights" mean the company has a legal right to access oil and gas resources in a specific area. The moratorium has delayed the issuing of licences. Usually companies have a five-year period with the possibility of renewal for another year. They have to drill or improve their holdings or these could revert to the government and be sold again. The moratorium has suspended this process. Until the moratorium is lifted, there will not be an opportunity for the company to act. In Alberta, the energy industry drills about 14,000 wells a year. Many times these rights are bought and sold or the company doesn't explore, and they revert back to the crown because government wants to see the resource developed. There is also the question of what regulatory framework and level of environmental impact assessment will be required. In terms of the regulatory road map that

provides for the exploratory stage but not the development stage, industry would not see this as an impediment because industry really starts with the exploratory phase.

Marine Transportation and Safety
POL 1.2.3 Overview

B. Frederking

Natural Resources Canada

MARINE TRANSPORTATION AND SAFETY POL OVERVIEW

West Coast Offshore Oil & Gas Workshop

January 2003

CHC NRC·CNRC

Strategic Intent

Fulfil federal government responsibilities while maximizing economic benefits and reducing environmental consequences from the expansion and diversification of Canada's oil and gas production.

CHC NRC·CNRC

Strategic Direction

Provide S&T to extend and diversify Canada's oil and gas production from offshore and northern regions through the development of the science and technology needed for standards and regulations, and to reduce costs and mitigate environmental and safety concerns. Priority will be given to R&D related to new sources of natural gas.

CHC NRC·CNRC

MTS POL Objective

Carry out R&D in aid of

- regulatory requirements for the safe and efficient transportation of oil and gas by tankers, and
- occupational safety standards in offshore operations.

CHC NRC·CNRC

MTS POL Rationale

- East Coast oil 15% → 25%
- Offshore oil production low energy intensity
- Federal responsibilities
  - Transportation
  - Safety (personnel and environment)

CHC NRC·CNRC

POL Plan

- 4-year duration
- Results based management
  - Outputs, milestones and deliverables
  - Outcomes, 3rd party uptake
  - Impacts
- *Performance measures*
  - Indicators, base, targets

CHC NRC·CNRC

POL Activities

- Offshore Safety
- Marine Operations
- Ship Design

  - International Cooperation

CHC NRC·CNRC

Offshore Safety Results Framework

Projects	Outputs	Outcomes
Escape, evacuation and rescue (EER) joint research *NRCan*	Draft EER performance standard.	Use of draft EER performance standard by offshore boards.
Evacuation systems in ice affected waters *NRC*	Performance measures for evacuation in ice Benchmark performance of existing evacuation systems	Selection and/or development of evacuation equipment and systems for deployment in ice on the basis of these performance measures. Incorporation into codes

CHC NRC·CNRC

Marine Operations Results Framework

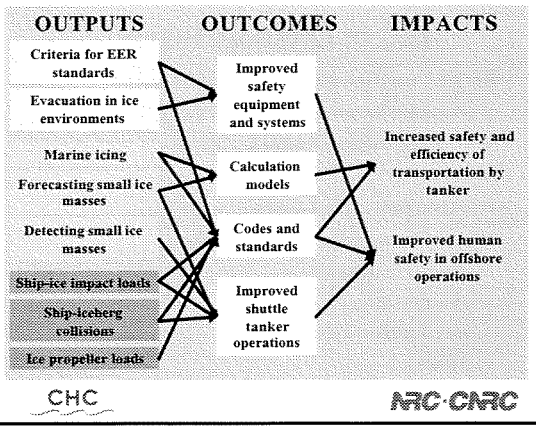
Projects	Outputs	Outcomes
Prediction of marine icing *NRC*	- Assembly and deployment of visual monitoring system - Upgrade of RIGICE computer model Database of icing severity for different environmental conditions	Use of the data in codes for the East Coast of Canada Use of the icing model by industry operators
Forecasting presence of small glacial masses *EC*	-improved understanding of evolution of calved ice pieces - refinement and evaluation of CIS bergy bit model - products available to shuttle tankers	- use of guidance products by shuttle tankers operating in iceberg infested waters - citation of work in scientific literature
Advanced Radar Systems *TC*	- shore based trials of radar with characterization of various ice targets in the sea - radar system ready for deployment on shuttle tanker	- operational use of radar on shuttle tankers

CHC NRC·CNRC

Ship Design Results Framework

Projects	Outputs	Outcomes
Bergy bit influence on marine transportation *NRC*	- numerical simulation model of ship impact with ice - global ice impact loads from 2001 Terry Fax trials - probabilistic pressure area relation for glacial ice impacts	-use of results by oil companies. - incorporation of results into codes and/or regulations
Ship-iceberg collision database *NRC*	- compilation of ship – iceberg collisions and associated fctors - preliminary risk analysis to produce relation between collisions and iceberg populations.	- use of database by regulators and operators for planning future projects - use or results in other research
Ice loads on propellers *TC*	Propeller damage analysis and relation to "Unified Requirements" load model.	Use of results in IACS UR for propellers.

CHC NRC·CNRC



CHC NRC·CNRC

POL Organization

- POL Leader
- OERD S&T Advisor
- Departmental Committee
- External Advisors
- Project Managers

CHC NRC·CNRC

POL Organization (a)

- POL Leader (R. Frederking, NRC)
- OERD S&T Advisor (S-L. Marshall)
- Departmental Committee
  - T. Carrieres (EC)
  - R. Gagnon (NRC
  - M. Hnetka (NRCan)
  - S. Prinsenberg (DFO)
  - P. Timonin (TC)

CHC NRC·CNRC

POL Organization (b)

External Advisors

- W. Bobby (CNOPB)
- A. Ewida (Petro-Canada)
- V. Santos-Pedro (TC)
- H. Vigen (Canship Ugland)

CHC NRC·CNRC

POL Organization (c)

Project Managers

- T. Carrieres (EC)
- R. Gagnon (NRC)
- C. Gautier (TC)
- B. Hill (NRC)
- M. Hnetka (NRCan)
- E. Radloff (TC)
- A. Simos Re (NRC)

CHC NRC·CNRC

Budget by Activity

Activity	02-03	03-04	*05-05*	*05-06*
1. Offshore Safety	180k	200k	*250k*	*250k*
2. Marine Operations	280k	250k	*210k*	*210k*
3. Ship Design	240k	250k	*240k*	*240k*

CHC NRC·CNRC

MTS Future Issues

- Other issues
  - Tanker loading and unloading
  - Personnel safety on FPSOs
  - Interest in frontier (Arctic)
  - West Coast

CHC NRC·CNRC

NRC in Offshore POLs

Environmental Forecasting and Design

- Ice-structure interaction (ISIAC)
  - Ice forecast model for CIS/EC

Northern

- Beaufort Sea experience for ice loads

Marine Transportation and Safety

- Bergy bit impact
- Marine Icing
- Evacuation in Ice
- EER

CHC NRC·CNRC

Institute for Marine Dynamics

Research Programs

- Ship technology
  hydrodynamics, ice effects, propulsion, ship dynamics
- Ocean engineering
  wave impact, flexible structures, scaling, numerical simulation

Facilities

- Ice Tank 90 m
- Offshore Engineering Basin 75 m by 32 m
- Towing Tank 200 m

CHC NRC·CNRC

Canadian Hydraulics Centre

Activities

- physical and numerical studies
- R&D

in fields of

- coastal engineering
- cold regions technology

Facilities

- 40 m offshore basin
- 100 m wave flume

CHC NRC·CNRC

Discussion

Events such as a crane toppling by wind at a coal port would not be in the domain of the Program at Objective Level (POL) because it is land-based infrastructure. Wind damage to shipping facilities is a design problem requiring appropriate 100-year wind loads. Within the ESRF there is a Canadian Standards Association (CSA – a standards development body) offshore structures code so ESRF has taxed itself to provide some funding for the CSA to revise the existing code.

Marine transportation is an international issue. Probably 0.1% of ships in the world are Canadian or Canadian registered so focus is on areas such as cold or ice issues that others will not do.

There could be unique meteorological or oceanic conditions on the West Coast since it is hard to imagine that you would not find some unique aspects. Codes are reliability-based, so this puts a lot of responsibility on operators to prove their designs will meet a reliability level. Codes say you should not be in any more peril on a marine structure than on a land-based structure.

Wind R&D falls under the area of wind and waves in the Offshore Environmental Factors POL as it continues to be identified as an issue by the oil and gas industry. It may not be funded to the level requested, but all POLs have good projects that have to be put off due to budget constraints.

On the West Coast, marine accidents have tended to be collisions between vessels. Although the West Coast has many congested areas and strong currents this has not received particular attention. The POL has a new proposal looking at marine collisions but this focuses on collisions during loading. Tankers are a small part of the overall marine traffic although they are relatively unwieldy.

Offshore Environmental Factors on Canada's East Coast

POL 1.2.1 Overview

P. Smith

Fisheries and Oceans Canada

Program of Energy Research and Development
Programme de recherche et de développement énergétiques

Offshore Environmental Factors on Canada's East Coast

Peter C. Smith, Leader
Offshore Environmental Factors POL
Program of Energy Research and Development (PERD)

Program of Energy Research and Development
Programme de recherche et de développement énergétiques

Outline

- What is OEF POL?
- Structure of OEF POL
- Process and Priorities
- Project Activities
- Results-based Management Framework
- Currents Research
- Wave Modelling

PERD West Coast Oil & Gas Workshop,
8-10 January 2003, Sydney, British Columbia

Program of Energy Research and Development
Programme de recherche et de développement énergétiques

Program at Objective Level (POL) 1.2.1

Strategic Intent # 1

- Fulfil federal government responsibilities while maximizing economic benefits and reducing environmental consequences from the expansion and diversification of Canada's oil and gas production.

Strategic Direction # 2

- Provide S&T to extend and diversify Canada's oil and gas production from offshore and northern regions through the development of the science and technology needed for standards and regulations, and to reduce costs and mitigate environmental and safety concerns Priority will be given to R&D related to new sources of natural gas.

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8-10 January 2003, Sydney, British Columbia

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Program at Objective Level (POL) 1.2.1 (cont.)

Objective # 1

- **To determine offshore environmental factors for regulatory, design, safety, and economic purposes. This includes the following activities:**
- Wind- and Wave-Hindcasting and Forecasting
- Sea Ice and Iceberg Detection and Forecasting
- Ocean Current Measurements and Circulation Modelling
- Ice-Structure Interaction Research and Standard Setting
- Seabed Stability Research and Development
- Basin Assessment Research

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OEF POL STRUCTURE

POL Committee

Chair:		Peter C. Smith
Departmental Representatives:		
EC	-	Val Swail
DFO	-	Simon Prinsenberg
NRC	-	Bob Frederking
NRCan	-	Gary Sonnichsen, Mark Williamson
Industry/Regulators:		
Terra Nova	-	Greg Lever
Petro-Can.	-	Jock McCracken
NEB	-	Bharat Dixit
CNOPB	-	Dave Burley
CNSOPB	-	Stuart Pinks (temp.)

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PROCESS (POL Cycle):

• **Consultation**	e.g. ACPI/CAPP Workshops
• **Proposals**	general call
• **Review**	POL Committee
• **Priority Setting**	POL Committee+OERD
• **Allocation**	POL Committee+OERD

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CURRENT ACTIVITIES:

- ***Wind and Waves***
  - Improved wind & wave offshore design criteria
  - Improved forecast models for wind waves
  - Novel techniques & instruments for observation of wind &wave fields
- ***Sea Ice and Icebergs***
  - Improved coupled ice-ocean forecast models.
  - New techniques for detection & assessment of ice hazards.
- ***Currents and Circulation***
  - High-resolution circulation models for impact studies and applications to regulations and engineering design
  - Observation and modelling of deep-water (slope) currents
  - Coupled forecast models for joint effects of surface currents & waves

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CURRENT ACTIVITIES (cont.):

- ***Ice-Structure Interaction***
  - Iceberg management and risks of collisions.
  - Iceberg interaction with the seabed
  - Determination of ice loads on floating structures
- ***Seabed Stability***
  - Regional geological framework and geohazards
  - Assessment of seabed foundation conditions
  - Dynamics, morphology & migration of bedforms
  - Iceberg scour & processes on NE Grand Bank
  - Regional assessment of critical soil properties.
- ***Basin Assessment***
  - Geological controls on 1) reservoir and source rock occurrence, productivity, and producibility, and 2) risks of abnormal pressure development
  - Nature/habitat and history of select pools and plays
  - Geological risk template for source and reservoir systems within prospective areas

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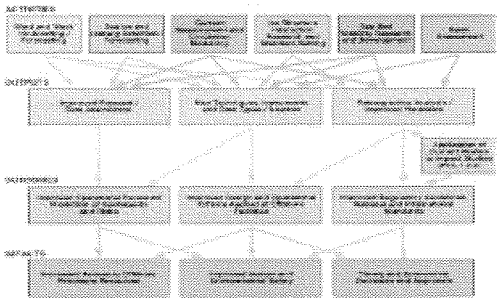
Framework for Results-Based Management



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FUTURE:

Modest Course Changes, Based on Advice derived from Industry/Regulators Consultations:

- Explore current properties and structures over the continental slope,
- Define deep water geohazards; perform slope stability assessments,
- Improve protection (i.e. detection, tracking, forecasting) from ice threats
- Enhance data collection and consolidation.

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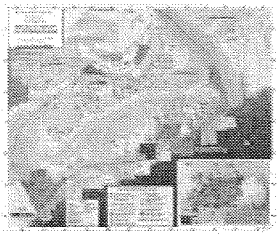
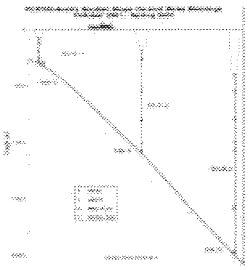
Currents and Circulation Research

Scotian Shelf Leases



Current Moorings



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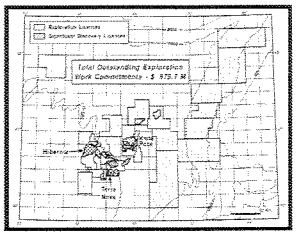
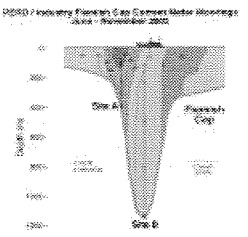
Currents and Circulation (cont.)

Flemish Pass Leases



Current Moorings



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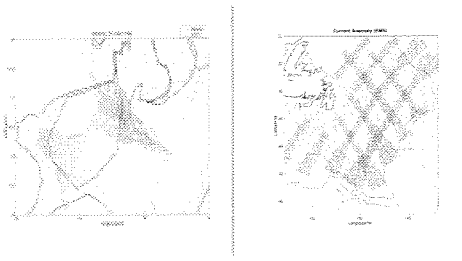
Currents and Circulation (cont.)

Altimeter vs. Shipborne ADCP **RMS Variability**



Fisheries and Oceans Canada / Pêches et Océans Canada

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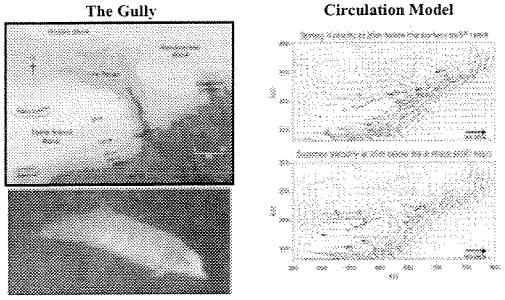
Currents and Circulation (cont.)

The Gully **Circulation Model**



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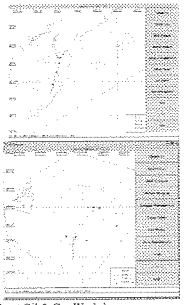
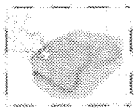
Currents and Circulation (cont.)



WebDrogue

A map based application for particle tracking in model flow fields.

- Point and click interface
- Download from web site



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Currents and Circulation (cont.)

WebTide

A map based application for generating tidal predictions from a tidal model

- Point and click interface
- Download from web site

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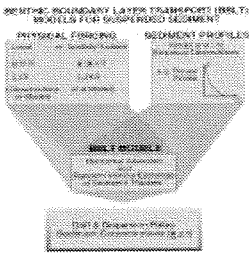
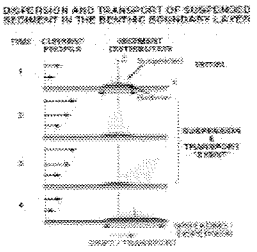
Currents and Circulation (cont.)

Model Structure **Benthic Transport Process**





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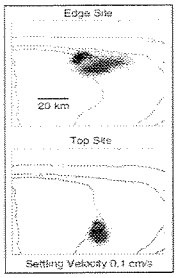
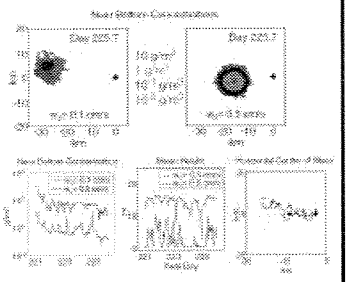
Currents and Circulation (cont.)

Sample Distributions **Sensitivity of Results**





Fisheries and Oceans Canada / Pêches et Océans Canada

Extreme storms and waves

Objectives:

1. **State-of-the-art operational / research wave model**
2. **Coupled atmosphere-ocean models for better winds, waves and currents**
3. **Big waves and severe storms: get better wave physics**
4. **Wave-current interactions: impacts of currents on wave**
5. **Energetics of storms: role of the oceans for developing peaks in storms and winds**
6. **Environmental extremes: estimation of possible biases in simulations of selected storms used in wave climate studies**

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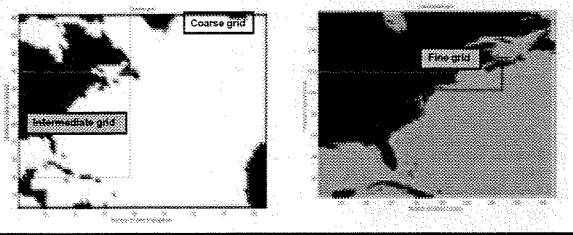
WaveWatch III (WW3) Coarse grid → WW3 Intermediate grid → SWAN Fine grid

State-of-the-art wave model



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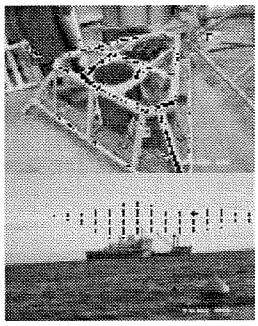
Wave Observations at BIO Site



ADCP

- principle: wave properties from accurate measures of orbital velocities
- 3 independent measures:
  - bottom pressure
  - orbital velocity
  - surface echo location

Directional Wave Rider (DWR)

- real-time data via ARGOS

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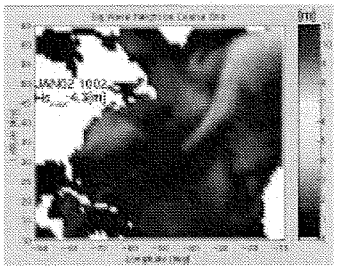
WW3 coarse grid: January 2002 GoMOOS Bomb

-storm-waves and swell propagation



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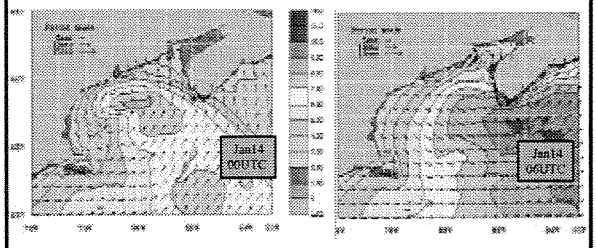
SWAN-Hs on Nested Fine grid



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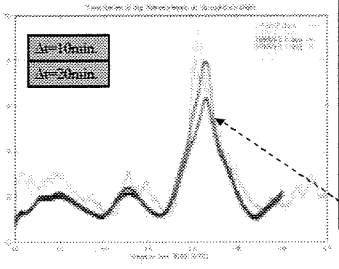
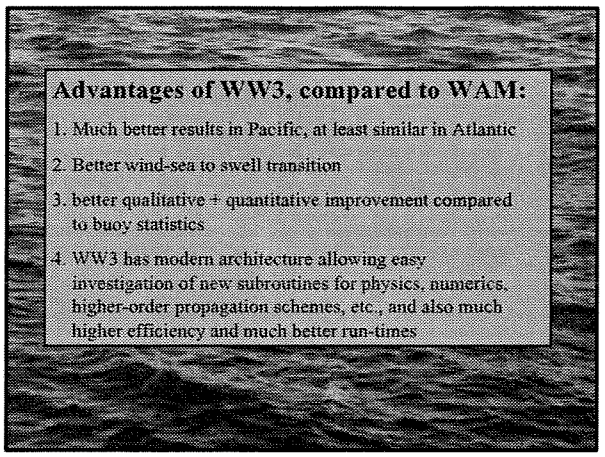
Verification: SWAN vs. BIO Observations

SWAN with WAM3 physics



- excellent agreement overall
- model and ADCP observations both show 8 m peak
- model lags observation by few hours
- SWAN 0.2° is lower



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Conclusions

- OEF POL 1.2.1 presently serves an active offshore O&G industry on the east coast;
- There are OEF tools and analyses developed on the east coast that could be transferred to west coast applications;
- This is the appropriate forum for initiating those discussions.

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West Coast OEF Proposals (2002/06)

- Extreme ocean currents in Hecate Strait (Crawford, Thomson, Foreman)
- Analysis, interpretation, and documentation of physical oceanographic current and water property data collected by F&O during NCODE (Thomson, Fissel)
- Development of a validated operational ocean current forecast model for the Queen Charlotte Sound and Hecate Strait (Thomson, Tinis, Foreman, Crawford)

Discussion

Bottom mounted wave sensors are really made for shallow water. The sensor was at 19 m, they would not work at 100 m. One using a higher frequency would work, but would not get as much resolution. Bottom pressure sensors would not be usable. The sensor was 1.2 MHz. 600 KHz actually works at 80 m (Woods Hole) with reasonable results. The two spectra from the bottom pressure and the orbital velocities agreed very well throughout the entire record. The surface echolocation is a bit fuzzy.

The East Coast "bomb" did not affect the offshore rigs as maximum waves occurred near shore.

PERD Wave and Marine Wind Projects 2002/03

OEF Wind and Waves Research

V. Swail

Environment Canada

PERD WAVE AND MARINE WIND PROJECTS 2002/03

12100A01 MSC Offshore Wind and Wave Design Criteria

12100A03 MSC Data Assimilation into Coupled Atmosphere-Ocean Wave Models

12100A04 DFO /MSC Extreme Storms and Waves

12100A02 MSC Validation of Buoy and Platform Wind and Wave Measurements

12100A05 DFO Hydrodynamic Loads on Slender Structures

12100A06 DFO Field Evaluation of Ocean Wind and Wave Estimates by Satellite-Borne and Marine Radar Systems

Appendix A – Resources

2001–2002 Resource Summary

POL 1.2.1

Funding Sources	
Organization	*Funds (k$)*
PERD – A. Wind and Waves	550
A-Base (list $ by department)	
EC	170
DFO/CCG	20
CHS	20
CCRS	10
Industry (list companies)	
Int'l Oil and Gas Prod. (OGP)	50
Oceanweather	25
Other (specify)	
CBLAST	10
GoMOOS	80
Canadian Space Agency	11
US Army Eng R&D Center	50
Southampton Oceanography	60
Dalhousie	5
Oxford University	5
CFCAS	15
TOTAL	1081

Outputs

A1: *Development of Improved Wind-Wave Hindcasts*

- North Atlantic 43-year wind-wave hindcasts.
- Wind and wave scenario modelling to the year 2100.
- Wave design criteria determination based on satellite altimeter data.
- MSC40 web page containing project description, validation results and extremal analysis
- 7th International Workshop on Wave Hindcasting and Forecasting;
  - coincident hosting of International Oil and Gas Producers (OGP) meeting, Oct. 17-25, 2002
  - www.oceanweather.com/7thwave

A2: *Development and Assessment of Instruments and Techniques for Wind, Wave*

- Assessment of methods for monitoring marine winds and waves, - buoys, ships
- Presentation of results to WMO Data Buoy Cooperation Panel meeting

A3: *Testing and Validation of New Data and Techniques for Forecasting and Monitoring*

- Improved physics in state-of-the art wave models, including atmospheric boundary layer-ocean coupling and feedback mechanisms, wave breaking and dissipation
- Evaluation of CMC regional wave forecasting system, intercomparison of operational wave forecasting systems, and shallow water intercomparison of wave models on Lake Erie
- Evaluation of high resolution and nested versions of the WAM in collaboration with MSC Atlantic
- Initial implementation and wave height simulations using high resolution and nested versions of WAM, Wavewatch-III and SWAN models nested with high resolution WAM for 2 recent extreme storms
- coupled atmosphere-ocean wave model: MC2 mesoscale atmosphere model and WAM ocean model.
- Investigated Canadian regional climate model CRCM, to simulate storms; coupling atmosphere-wave-oceanic models can give >10% effects on wave heights in high storm conditions.
- Developed improved computer codes for wave-wave interactions
- Analysis wave model sensitivity to currents; shows currents important (>10%) in high current conditions.
- Show wave impacts on surface currents during storms can be ~ 40% of the current magnitudes
- New computer coding of the heat flux effects of sea spray
- Calibrate high-resolution (<5km) RADARSAT SAR wind fields for severe storm, hurricane conditions
- **A1-A3 total:** Results disseminated to scientists and industry through series of publications – 36

Outcomes

A.1: *Application of Wind and Wave Hindcast Results*

43-year database of high-quality continuous wind and wave hindcasts has been used extensively by industry in several east coast offshore projects during the year, including Petro-Canada, Pan Canadian, Exxon/Mobil, Chevron/Texaco, BP, Marathon and Shell, and by regulatory authorities in several Environmental Assessments.

Hindcast data base and statistics used by DFO-MEDS in wave climate program

Hindcast data base and statistics used by Canadian Coast Guard in Search and Rescue R&D program

Hindcast data base and statistics provided to R&D projects in PERD Climate Change Impacts on the Energy Sector POL

A.2: *Application of Improved Wind-Wave Models for More Accurate Operational Forecasts*

MSC is significantly increasing the resolution of their wave model grid.

MSC and BIO have established a new cooperative research program to extensively compare the WAM model that is used operationally with newer models such as WW3 and SWAN.

Industry consultants have entered a partnership with BIO-MSC in testing new models, SWAN, at high resolution implementations, for areas around hydrocarbon sites.

Wave model intercomparison results are used by international centers to identify areas of potential improvements of various operational ocean wave forecasting systems (winds and waves), as part of a WMO program

Nested versions of WAM are being used by the Atlantic Region to produce more accurate ocean wave forecasts for the Northwest Atlantic.

Monitoring of wave model performance has led to the identification of a possible incorrect implementation of the WAM Cycle-4 in the international near shore SWAN model.

WIND AND WAVE DESIGN CRITERIA

GOAL: to reduce the uncertainty in wind and wave design criteria off the east coast of Canada

In order to achieve this goal the R&D plan has two important components:

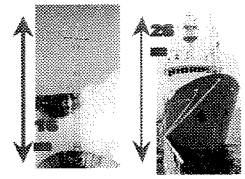
(A) to investigate (1) the problems with specification of wind speeds due to measurement uncertainties in ship, platform, buoy and satellite winds which form the basis for the analysis, and (2) mesoscale features embedded in the synoptic scale flow which contribute additional energy

(B) to develop and apply wind and wavehindcast methodologies to translate those research results into reliable design criteria.

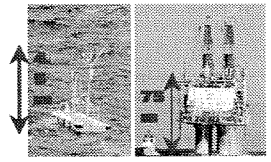
R&D ACTIVITIES RELATED TO REDUCTION OF UNCERTAINTY IN DESIGN WIND AND WAVE ESTIMATES

- Flow distortion study
- Wind and Wave Measurement Evaluation (SWS)
- Wind Field Enhancements in Hindcast – WindWorkstation©
- Extension of hindcast to 1956-2002
- Tropical Storm Transition
- Wave climate trend and variability
- Web Page for MSC-40
- Extreme Value Analysis – methodology and sampling rate
- Altimeter-based wave criteria
- Climate Scenario projection (with CCIES)
- 7th Waves Workshop (www.oceanweather.com/7thwave)

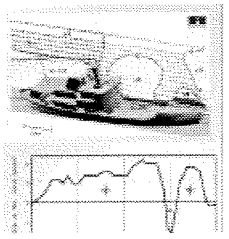
Adjustment of Marine Wind Data



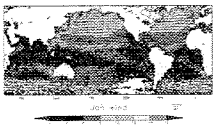
Some reasons for adjustment



Effect of flow distortion and sheltering (project with SOC)



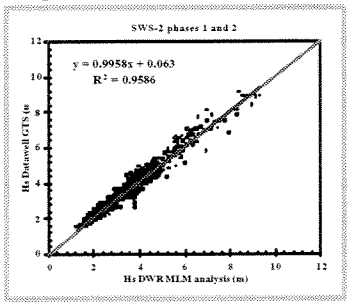
Adjusted COADS data product (interim)



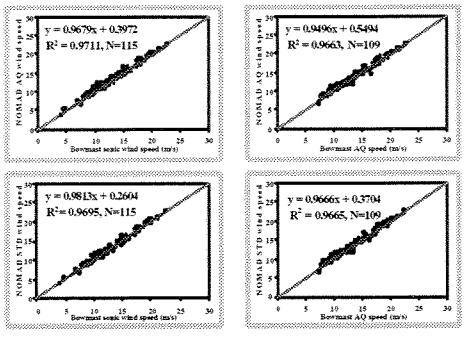
Source: CRB Storm Wind Study II (on Grand Banks)

V. Swail and B. Hansen

NOMAD Datawell and DWR Significant Wave Height



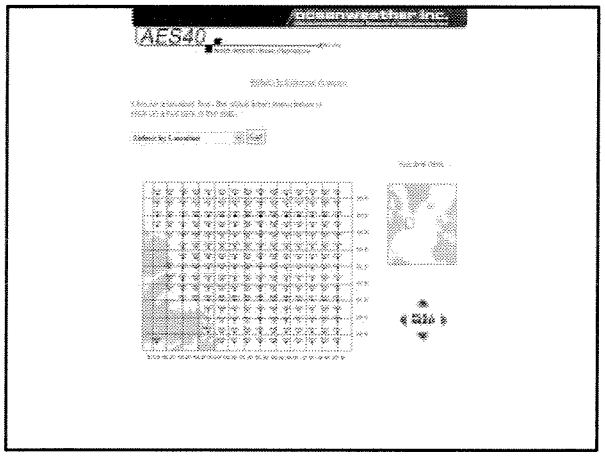
NOMAD and Bow-Mast Wind Speed

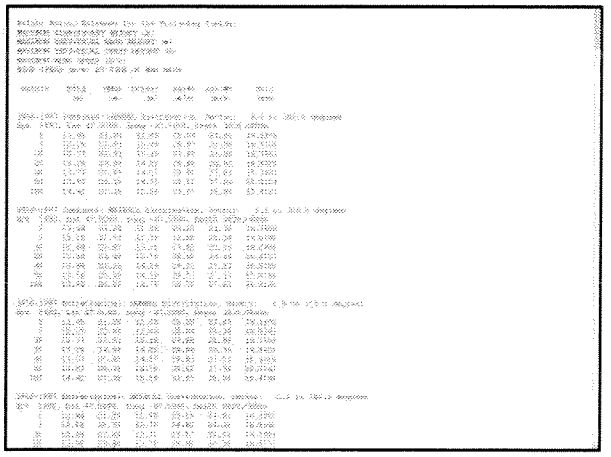


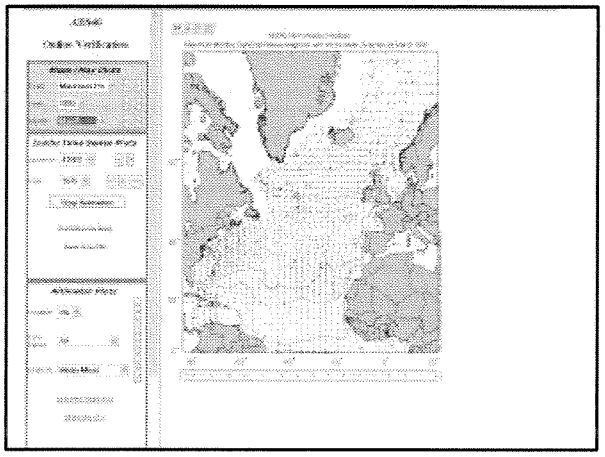
NORTH ATLANTIC WIND AND WAVE REANALYSIS

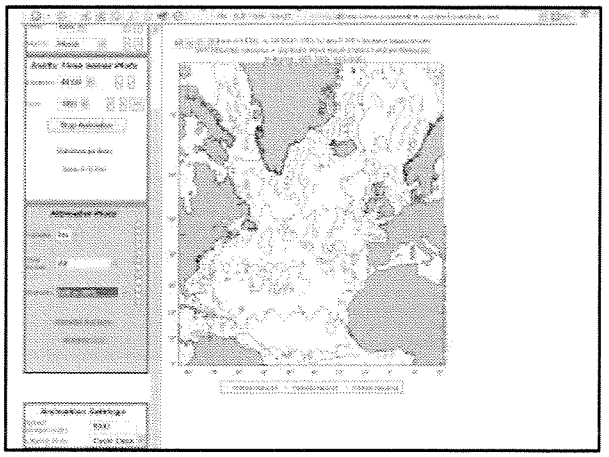
OBJECTIVE

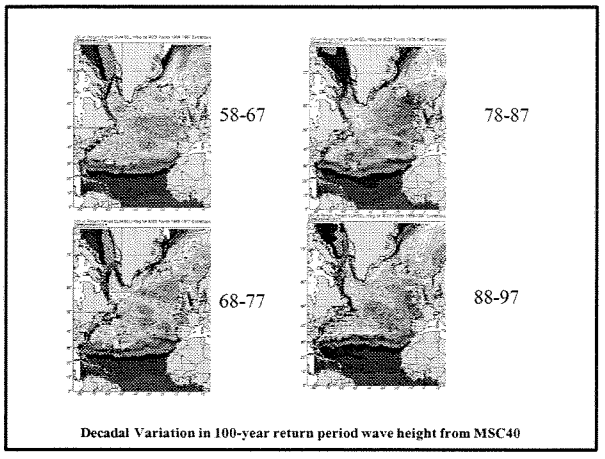
To produce a ***high quality, homogeneous, long term*** wind and wave data base for assessment of trend and variability in the wave and storm climate of the North Atlantic Ocean



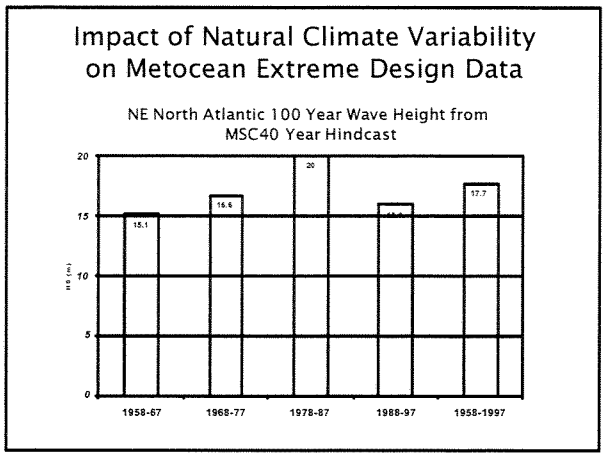




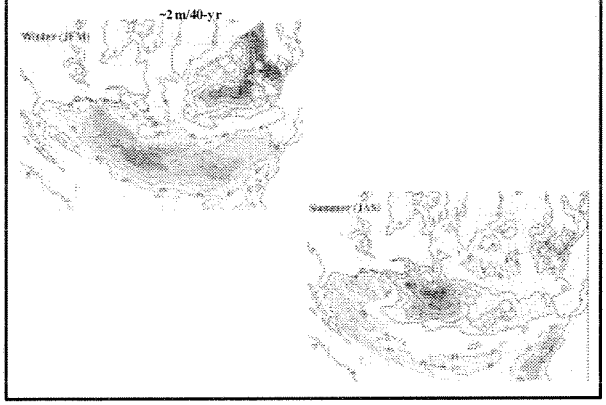




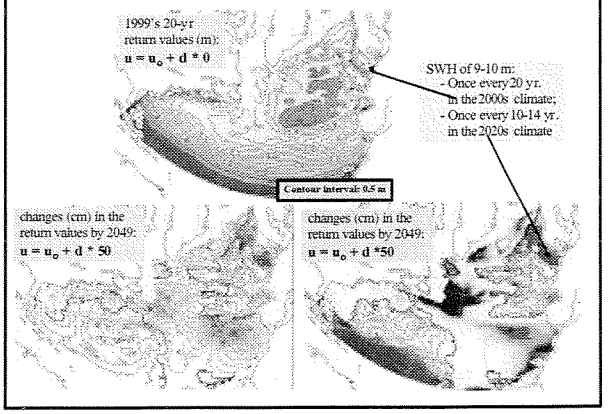
Decadal Variation in 100-year return period wave height from MSC40

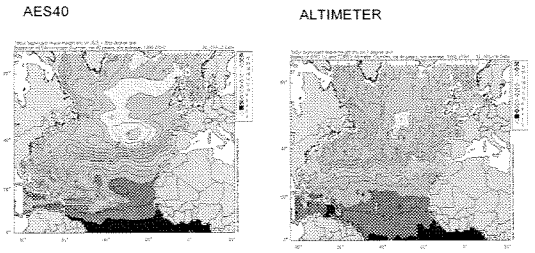


Seasonal 90-percentiles: 40-year changes/mean. Hatching: significant at least at 5% level



Winter maxima - changes in return values/periods (IS92a scenario mean)





FUTURE R&D ACTIVITIES IN DESIGN WIND AND WAVES INCLUDE THE FOLLOWING

- Kinematic Wind Field Enhancements in Hindcasts especially in extreme storms
- More timely updating of recent years – issues with NHC
- Extension of hindcast to 50 years
  - on finer scale grid, down to 0.1 degrees, at least in nests
  - Incorporating shallow water effects
  - On 1-hour time scale
  - Saving 2-D spectra at every grid point
  - Timing depends on potential industry partnerships – Shell, Marathon, Exxon/Mobil, Chevron

Waves on Sable Island Bank and the Grand Banks

Objectives

1. Implement and test models for routine high resolution wave forecasts, including shallow water and currents.
2. Investigate extreme waves for Scotian Shelf, the Grand Banks and related Atlantic Canada areas - test new science
3. Document biases and limitations in wave models and recommendations related to potential implementation.

Motivation

Marine Storms/severe cases